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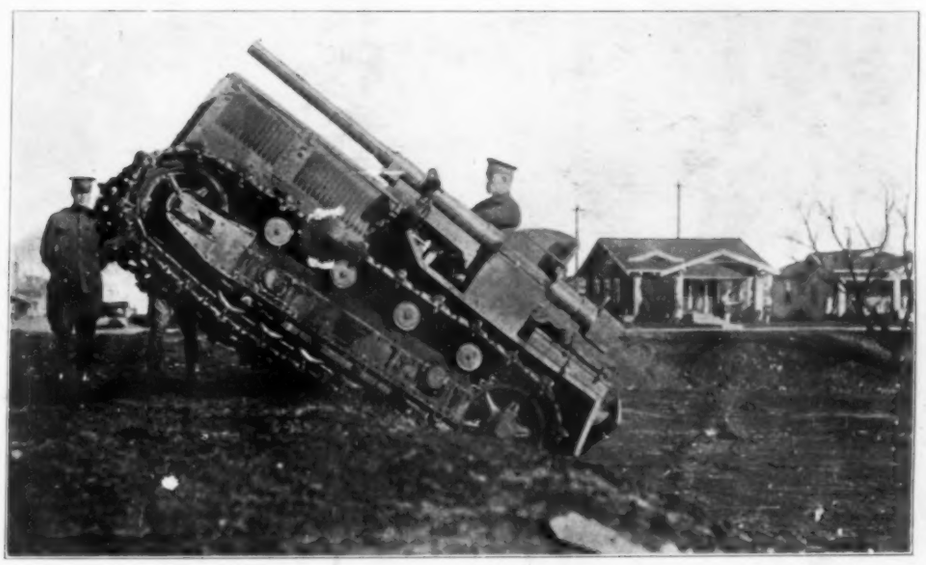

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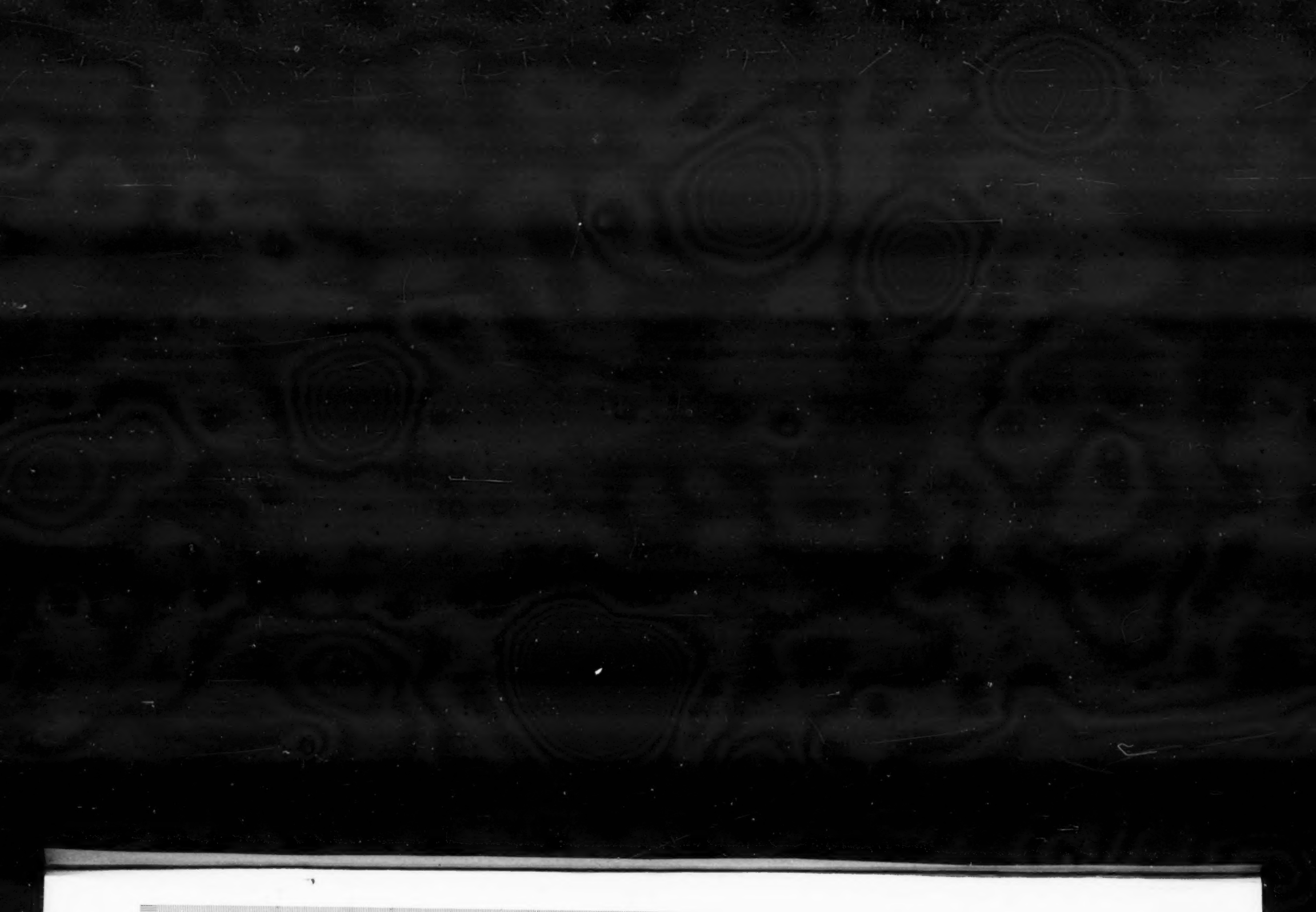

ARMY ORDNANCE

THE JOURNAL OF THE ARMY ORDNANCE ASSOCIATION

Pledged to Public Service in Effecting Industrial Preparedness for War as Our Strongest Guarantee of Peace

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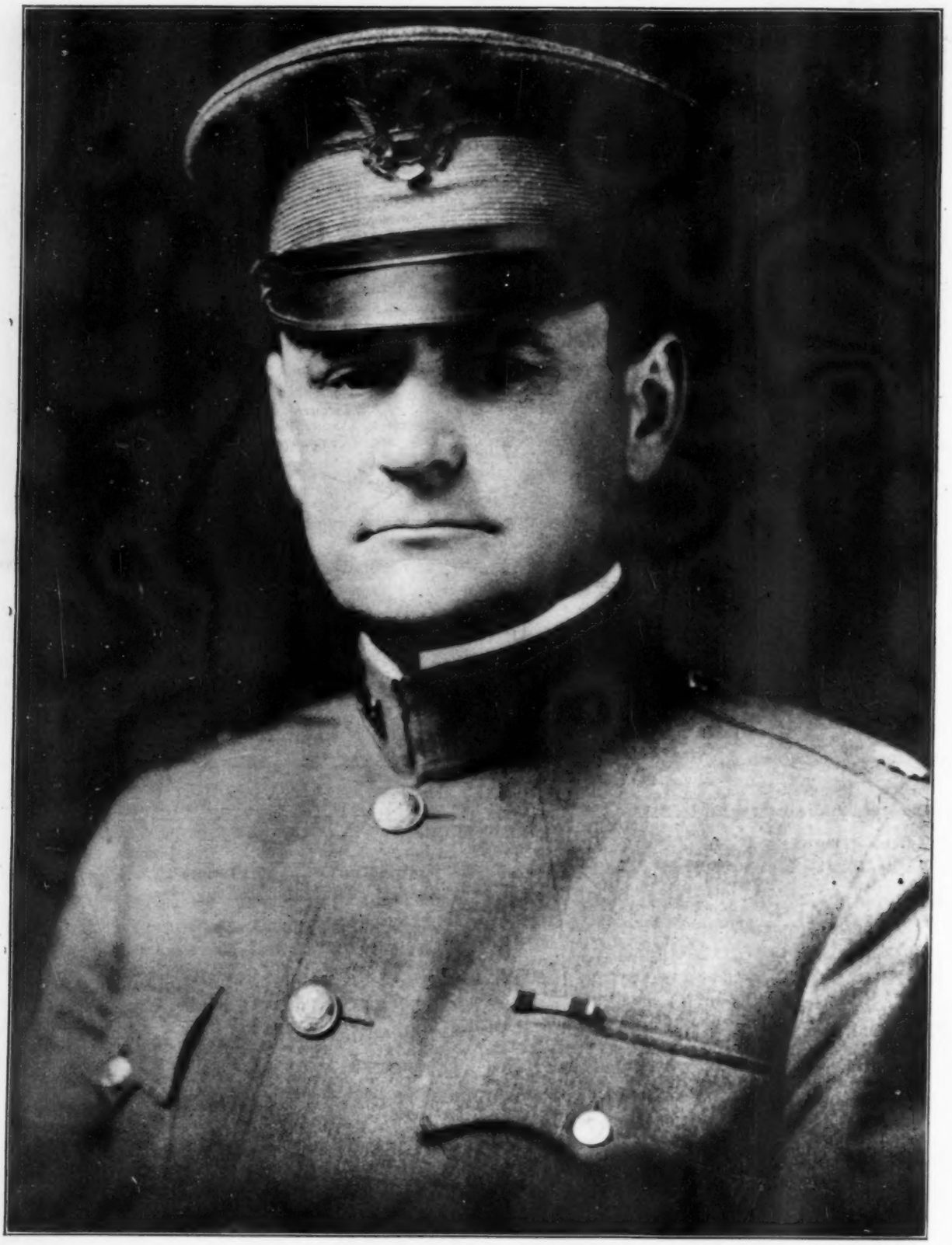

Major General C. C. Williams

Reappointed Chief of Ordnance, United States Army, for a period of four years, from July 16, 1922

Resignation of Colonel James L. Walsh

IT will be a matter of interest as well as a source of keen regret to the members of the Army Ordnance Association to learn that at a meeting of the Board of Directors held on June 16, 1922, Colonel James L. Walsh tendered his resignation as Secretary of the Association and Editor of ARMY ORDNANCE.

In accordance with War Department policy, Colonel Walsh was due to be relieved from duty in Washington, D. C., at an early date, and as it was deemed essential that the Secretary of the Association and Editor of the Journal be an Ordnance Officer on duty in Washington, these circumstances impelled Colonel Walsh to submit his resignation, which was accepted by the Board with expressions of sincere regret.

Colonel Walsh

At the close of the war, millions of Americans had the need for strictly military preparedness strongly impressed upon their consciousness, but only a few who had handled the major phases of the stupendous problem of manufacturing arms and munitions for the mobilized man-power realized that preparedness confined to problems of man-power alone would be futile—that the crux of the whole matter of preparing the nation to maintain its sovereignty rested in taking prompt and active measures to insure that industry would be mobilized to supply those material things without which our man-power would be but food for cannon of the enemy.

Among those who sensed the vital importance of adequate *industrial preparedness* was Colonel Walsh, then Executive Assistant to the Chief of Ordnance, who realized, too, that the solution of this grave problem could never be attempted successfully within the Army solely, but must engage the assistance of American Science, Engineering and Industry at large and maintain interest in ordnance manufacture on the part of those who had rallied to the nation's call in the trying hours of need in 1917-1918.

Not content with merely perceiving the need, he turned his thoughts and energies to devise a means to accomplish something practical toward correcting the situation. In order to coordinate the activities of those who saw the problem in the same light as himself, as well as to secure additional help from those whose sense of duty would lend itself to practical peace-time patriotism, he lent himself most earnestly and energetically to organizing the Army Ordnance Association. From the very beginning, the Association has been primarily one of civilians, recruited either from those who served in the Ordnance Department during the war or who manufactured ordnance for the Department in their own plants, the total membership being ten times the numerical commissioned strength of the Regular Army Ordnance Department. In view of the preponderant proportion of civilian membership, and at the suggestion of Colonel Walsh, the Constitution and By-Laws of the Association were drawn so as to perpetuate control of its activities in the hands of those who constitute the majority of its membership. As early as 1919, the By-Laws of the Association provided for the organization of the Association into Districts territorially similar to the Ordnance Districts which have just been established by War Department order, thereby having ready for immediate use a volunteer auxiliary body capable of rendering tremendous assistance to the small governmental organization which available appropriations now permit. Colonel Walsh's far-seeing grasp of the situation has therefore been of inestimable assistance in providing a going concern without which the successful operation of the present District system of industrial mobilization would prove difficult if not altogether impossible.

In order to maintain interest on the part of old members and to secure new members, Colonel Walsh

suggested and helped to carry through to successful accomplishment three annual meetings at the Aberdeen Proving Ground, which have brought incalculable benefit to the Ordnance Department—and thereby to the country—in the reawakened interest and resulting cooperation on the part of manufacturers who attended these demonstrations of post-war developments in Ordnance. Probably his g r e a t est accomplishment was, however, the establishment and successful operation of ARMY ORDNANCE, recognized to-day as the leading journal on ordnance subjects both in the United States and abroad. Probably no one who has not followed closely the inception and initial efforts of this undertaking realizes the difficulties encountered and overcome. To begin with, the enterprise was inaugurated just prior to what proved to be the worst industrial depression experienced by the United States in a decade. Patriotism was at a discount, members were hard to get and still harder to hold, advertising income, upon which magazines must depend very largely for existence, was more and more difficult to build up as business conditions grew worse, but through it all Colonel Walsh never wavered in his determination to put through the enterprise at whatever cost to himself. His earnestness and sincerity, and the high patriotic plane upon which he placed all of the Association's efforts finally gained recognition and appreciation, and in spite of difficulties which would have blasted any ordinary business enterprise at its very inception, ARMY ORDNANCE became better and better with each succeeding number until to-day its first two volumes stand as a monument to the man to whom the Association owes, not only its enviable position in the world generally but, in fact, its very existence.

Benedict Crowell, *President*
William W. Coleman, *Vice-President*
Ralph Crews, *Counsel*
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June 16, 1922

RESOLUTION OF BOARD OF DIRECTORS
ARMY ORDNANCE ASSOCIATION

MINUTES OF MEETING

IN accepting the resignation of Colonel Walsh, the Board of Directors desires to enter upon the Minutes its feeling of sincere regret for the necessity of this action and its full appreciation that the present success of the Army Ordnance Association and of ARMY ORDNANCE *has been due almost entirely to his enthusiasm and untiring efforts in the interests of the Association.*

Official:
R. H. SOMERS,
Secretary.

BENEDICT CROWELL,
President.

For his services in the World War, Colonel Walsh was awarded the Distinguished Service Medal, the citation of award reading as follows:

"For exceptionally meritorious and distinguished services in a position of great responsibility, first as Chief of the Personnel Division, Office of the Chief of Ordnance, which he organized and administered with conspicuous success during the first nine months of the war, a critical period, during which all Ordnance activities depended upon the successful handling of the personnel problem; and later as personal and executive assistant to the Chief of Ordnance, in which capacity his breadth of vision, tact, sound judgment and loyalty were invaluable to the Government in the numerous highly confidential matters entrusted to his care. In each of these positions his services to the Government were highly conspicuous and eminent."

Colonel Walsh has been succeeded as Secretary of the Association and Editor of ARMY ORDNANCE by Major R. H. Somers, who assumed his duties immediately after his election at the meeting of the Board of Directors on June 16, 1922. The general editorial policy will be unchanged.

The Ordnance Problem

By

C. C. WILLIAMS
Chief of Ordnance, U. S. Army
Member A. O. A.

1. Growth of Munitions Consumption

WHILE it is a matter of general knowledge today that munitions play an increasingly important part in modern warfare, it is helpful in obtaining a proper perspective of the Ordnance Problem, to draw a few comparisons between the munitions requirements of a present day army and those of the armies of the past.

Figures 1 to 4, inclusive, are very illuminating in this connection.* They give, respectively, the

(1) Expenditure of artillery ammunition in modern battles.
(2) Rate of artillery fire per gun per day in recent wars.
(3) Expenditure of artillery ammunition in recent wars.
(4) Comparative costs of equipping and maintaining Civil War and World War units.

These figures show clearly that the consumption of munitions in warfare has grown at a tremendous rate and indicate that this growth will continue in the wars to come. In a major war of long duration the consumption will only be limited by the power of the country to produce, and this in turn will be dependent upon the raw material resources and the industrial development of the country.

An illuminating comparison is also furnished between the initial cost of the ordnance equipment for the Army of General Rosecrans during the Civil War (which had a total strength of about 22,000 men), and the cost of the ordnance equipment for a division, plus its percentage of supporting Corps, Army and G. H. Q. troops during the recent war (which represented a total strength of about 40,000 men). The figures are, respectively, $645,000 and $6,575,000, or, in terms of cost of equipment per man, $29.30 and $164.37. In other words, developments in mechanical, chemical and electrical engineering, as applied to war, are such that the material factor in comparison with the personnel has increased over 500 per cent during the last sixty years. This is, of course, merely the military aspect of the industrial revolution which has been in process more than a hundred years. There is not the slightest indication that this tendency will not continue indefinitely.

It will be admitted that the time has arrived when the country's military strength is directly applied against the enemy almost entirely through the medium of chemical ammunition placed in the enemy's area by means of gun, aircraft, or other form of transportation.

2. The Mission of the Ordnance Department

It follows, therefore, that the real mission of the Ordnance Department is, in general terms, to endeavor to make arrangements for an adequate supply of the most effective munitions the country's resources and engineering ability are able to produce. This supply should, at the minimum, be equal in quality and quantity to those available to our enemy.

*Figures 1, 2, and 3 are taken from "How America Went to War," by Crowell and Wilson.

3. General Solution

The solution does not rest entirely with the Ordnance Department, but is the combined task of Congress, the War Department, the Users of Munitions or the Line of the Army, and the Makers of Munitions or the Ordnance Department with the assistance of the mobilized industry of the nation.

Congress is the basic authority and the real source of power, inasmuch as no funds are available except in accordance with its laws and appropriations.

The office of the Secretary of War and his representatives pass upon the estimates submittted to Congress and control expenditures authorized by Congress. His office controls also, subject to legislative limitations, the quantity of munitions required.

It is the task of the Users of Munitions to outline the character of munitions desired and to make recommendation on the satisfactoriness of the designs developed by the Ordnance Department.

The Ordnance solution is dependent upon a well developed organization, a rounded out personnel system, a comprehensive arsenal system, a well worked-out system for the production of munitions by commercial plants, a comprehensive system for storage and issue of ordnance, and especially a more clearly defined munitions policy which is satisfactory to the higher military authorities in the Executive Department of the Government and has the continuing support of Congress.

4. The Organization of the Ordnance Department

The chart on page 9 indicates the present organization of the Ordnance Department.* It is the result of many years of evolution and is, of course, gradually changing to keep pace with new requirements and new limitations. Its present form is, in large part, a direct result of World War experience.

The basic principles of the organization are as follows: The work of the department is divided into the following main sub-divisions: Design, Manufacture, Issue. General design control is centered in the Technical Staff. The Manufacturing Service has charge of the design, manufacture and procurement of ordnance. The Field Service has complete charge of the storage, issue, and maintenance of ordnance after it has been produced by the Manufacturing Service.

Finance control is centered in the Fiscal Office. Arrangements also exist for control of administration, routine, salvage, etc.

(1) Technical Staff.

The Technical Staff is the official point of contact of the Ordnance Department with the users of munitions or the Line of the Army in the matter of designs of ordnance. Its function is to establish policies for the development of different classes of material which are in harmony with

*This organization has been slightly modified recently, due to lack of personnel. It is, however, the organization which is considered best and which would immediately be put into effect in the event of an emergency.

the needs of the using services and to insure that those lines of development are followed by the Manufacturing Service in the actual work of development, study, and design. A number of officers representative of each combatant branch of the Army: The Infantry, Cavalry, Field Artillery, Air Service, Chemical Warfare Service, etc., sit with the Ordnance Officers as a committee on which also there sits a duly accredited representative of the Navy Bureau of Ordnance. This committee passes upon all questions as to lines of development, priorities in development work, approval of studies, judgment of tests of types, etc. This results in a very close co-operation between the several branches of the military establishment, and, it will be noted, has the additional advantage of having the Navy point of view on every question brought up. After a design has been satisfactorily developed under such control, it is submitted by the Chief of Ordnance to the General Staff for final approval.

(2) The Manufacturing Service.

The Manufacturing Service, under the general control of the Technical Staff outlined above, carries on the development and design work of the Department. It has full charge of the manufacture and procurement of ordnance, covering the complete field of raw and intermediate materials and their fabrication into issue articles of ordnance. It controls the manufacturing arsenals of the Department and is responsible for keeping in touch with the resources and commercial plants of the country with the object of not only ascertaining the dependence that can be placed upon them in time of war, but also of assisting in the increase of this dependence.

(3) The Field Service.

The Ordnance Field Service, established by War Department Orders in 1919, is responsible for storing the reserves of the issue articles produced by the Manufacturing Service, and especially for supplying the army with munitions and for keeping such supplies in a condition satisfactory to the users. The reserves are kept in various arsenals and storage depots under charge of the Washington office. Issues to troops and maintenance of munitions in the hands of troops are controlled by Corps Area Commanders, each of whom has on his staff a Corps Area Ordnance Officer. Issues are made by the proper arsenal or storage depot upon requisitions approved by Corps Area Headquarters, all in accordance with the tables of basic allowances approved by the War Department. Repairs and alterations are conducted by the Ordnance Maintenance Companies which are part of divisions, by special mechanics attached to Corps Headquarters or to Posts, or by Depots or Arsenals.

This close touch with the actual users of Ordnance has been, and it is hoped will continue to be, of great help to the Ordnance Department in its efforts to give the Line the types of fighting materials desired by it.

5. Personnel System

The personnel of the Ordnance Department is comprised of three classes: officers, civilians, and soldiers.

The officers are in reality the general managers of the Department and control the establishment of the ordnance problem, the plans for its solution, and the execution of the plans, including design, development, and procurement of munitions and their issue and maintenance.

The civilians are the backbone of the Ordnance Department in the matter of design, development, and procurement of munitions.

The soldiers are the field force of the Department for issuing munitions to troops and for maintaining such munitions in a condition satisfactory to the users.

(1) Training.

To have an efficient personnel, each class must be trained to properly perform its function.

(a) Officers.

The officer must be thoroughly educated technically in order to insure that the latest developments in chemistry, metallurgy, and engineering are applied to munitions designs and procurement. He should be trained to administer the tasks of constructing and operating manufacturing plants and depots in an efficient and economical manner. He must be well acquainted with the needs and troubles of the actual users of munitions. He must understand the War Plans of the Government in the matter of munitions, be acquainted with the steps proposed to meet them, and be prepared to execute efficiently the agreed upon solution.

The training system covers the above as follows: The basic school of the department has been established at Watertown Arsenal, Watertown, Mass. The course is two years. One year is spent at the Massachusetts Institute of Technology at which the following subjects are taught: Advanced Mathematics, Theory of Elasticity, Chemistry (specializing in powders and explosives), Electricity, Heat, Power, and Ordnance Engineering. The second year is spent at Watertown Arsenal, largely in practical shop work. To give officers specialized training to fit them for particular phases of ordnance work, various post graduate and special courses are provided and each manu-

FIGURE 1

Expenditure of Artillery Ammunition in Modern Battles

Year	Battle	Days' duration	Army	Rounds of artillery ammunition expended
1863	Chickamauga	2	Union	7,325
1863	Gettysburg	3	Union	32,781
1870	St. Privat	1	German	39,000
1904	Nan Shan	1	Japanese	34,047
1904	Liao Yang	9	Russian	134,400
1904	Sha Ho	9	Russian	274,360
1915	Neuve Chapelle	[1] 3	British	197,000
1915	Souchez	[2] 1	French	300,000
1916	Somme	[3] 7	British	4,000,000
1917	Messines Ridge	[3] 7	British	2,753,000
1918	St. Mihiel	[2] 4	United States	1,093,217

[1] Artillery preparation lasted 35 minutes. [2] Artillery preparation lasted 4 hours.
[3] Artillery preparation intermittent 7 days.

One of the most striking developments of the recent war was the great increase in the use of artillery to precede infantry action in battle. This is illustrated by a comparison of the expenditure of artillery ammunition in characteristic battles of past wars with that in important battles of the war just ended. The special features of the several battles should be kept in mind. Chickamauga was fought in a heavily wooded region; Gettysburg and St. Privat over open farm land. The latter battles, together with Nan Shan, and all the battles of the World War considered above, involved artillery preparation for assault upon armies in defensive position. The expenditures, therefore, are roughly comparable.

The high mark of the use of artillery in offensive battle was reached at the Somme and Messines Ridge, before the effective use of tanks was developed.

facturing establishment is a training school for its officers. For example: Picatinny Arsenal specializes in chemistry and ammunition.

Arsenal duty is relied upon to train officers in the business administration of construction and operation.

Service with troops as Division Ordnance Officers, etc., or duty at Corps Area Headquarters is expected to give Ordnance Officers a proper conception of the munitions needs and troubles of the Line of the Army.

The Ordnance Department hopes to submit each year a rather detailed solution of whatever war plan the War Department may approve. In the working out of such solution, many officers of the Department will be required to assist. It is hoped that this plan will keep alive to some extent the knowledge of not only what the war munitions problem is, but also of some method of solving it. In addition to this, it is planned to have the officers serve a proper portion of their time in Washington when they will come in more intimate contact with the probable war plans of the Army.

FIGURE 2

Rates of Artillery Fire per Gun per Day in Recent Wars

War	Army	Approximate rounds per gun per day
1854–56, Crimean	British and French	[1] 5
1859, Italian	Austrian	.3
1861–65, Civil	Union	4
1866, Austro-Prussian	Austrian	2.2
	Prussian	.8
1870–71, Franco-Prussian	German	[2] 1.1
1904–05, Russo-Japanese	Russian	4
1912–13, Balkan	Bulgarian	7
World War		
September, 1914	French	[2] 8
Jan. 1–Oct. 1, 1918	Italian	[2] 8
Jan. 1—Nov. 11, 1918	United States	[2] 30
Jan. 1–Nov. 11, 1918	French	[2] 34
Jan. 1–Nov. 11, 1918	British	[2] 35

[1] Siege of Sebastopol. [2] Field-gun ammunition only.

The rates are based upon total expenditure and average number of guns in the hands of field armies for the period of the wars.

A large part of the heavy expenditure of artillery ammunition in the last as compared with other modern wars can be attributed to the increased rate of fire made possible by improved methods of supply in the field and by the rapid-fire guns now in use. In wars fought before the introduction of quick-firing field guns, four or five rounds a day was the greatest average rate. Even this was reached only in the siege of Sebastopol, where armies were stationary and supply by water was easy, and in the American Civil War, which was characterized by advanced tactical developments. The guns of the Allied armies in France fired throughout the year 1918 at a rate about seven times greater than these previous high rates.

(b) Civilians.

The Washington office and the work at arsenals and depots are the training system for the civilians. In time of peace they are not generally moved from one class of work to another or from one locality to another. Their training, therefore, is a natural result of the work on which they are engaged. This condition is of great importance to the Department for it is through the civilian force that the continuity of knowledge and experience, which is so necessary to any endeavor, lives. Without a well-trained civilian force, the Ordnance Department would be greatly handicapped. In other words, we must maintain a reasonable amount of work at our arsenals and depots at all times to keep together the nucleus of this force.

(c) Soldiers

They are given any special training necessary at the Specialists School at Raritan Arsenal which covers storage, supply and maintenance of ordnance.

2. Recruiting System

In addition to the officers of the regular establishment and in order to have sufficient officers for war needs, it is planned to have officers commissioned in time of peace in the Reserve Corps. They are obtained from the Ordnance R. O. T. C. Units at schools and from the part of the business world where the activities closely parallel those of the Ordnance Department.

It is also planned to keep them in touch with Ordnance activities by correspondence school methods, by calling them into active service at summer encampments, or by duty at an arsenal or ordnance establishment if possible.

It is also planned to institute at every ordnance establishment, immediately upon the start of war, schools for the training of newly commissioned officers, candidates for commission, and civilians

Civilians are recruited in accordance with the business principle of supply and demand under Civil Service Control.

Soldiers are recruited in accordance with War Department practice.

6. Arsenal System

The work of the Ordnance Department, for purposes of development and manufacture, has been divided into sev-

FIGURE 3

Expenditure of Artillery Ammunition in Recent Wars Past Wars Compared with One Month of World War

Year	War	Army	Rounds expended during war
1859	Italian	Austrian	15,326
1861–65	Civil	Union	5,000,000
1866	Austro-Prussian	Prussian	36,199
		Austrian	96,472
1870–71	Franco-Prussian	German	817,000
1904–05	Russo-Japanese	Russian	954,000
1912–13	Balkan	Bulgarian	700,000
1918	World	British and French	In one month.[1] 12,710,000

Expenditures for One Year, Civil and World Wars

1864 [2]	Civil	Union	1,950,000
1918 [3]	World	United States	8,100,000
1918 [3]	World	British	71,445,000
1918 [3]	World	French	81,070,000

[1] Average, year ended November 10, 1918. [2] Year ended June 30, 1864. [3] Year ended November 10, 1918.

The industrial effort necessary to maintain modern armies in action may be measured to a certain extent by their expenditure of artillery ammunition. European wars of the past hundred years were for the most part decided before peace-time reserves had been exhausted. The American Civil War, however, required for its decision an industrial mobilization at that time unprecedented, which, like the use in that war of intrenchments by field armies, was more truly indicative of the trend of modern warfare than were the conditions of the more recent European wars.

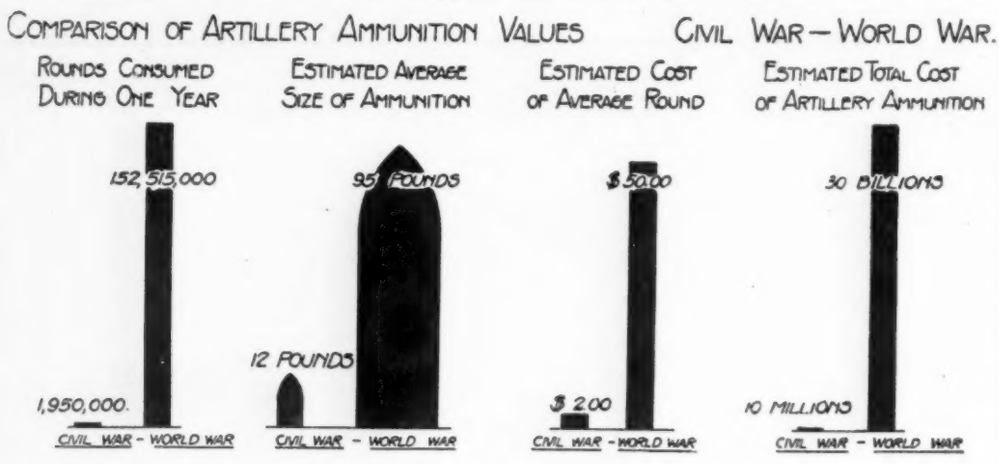


Fig. 4.

eral main classes covering similar or interlocking activities, and one or more classes have been assigned to each arsenal. These main classes and their assignments are: Small arms, Springfield Armory; small arms ammunition, Frankford Arsenal; cannon, Watervliet Arsenal; mobile artillery carriages, Rock Island Arsenal; heavy artillery carriages, Watertown Arsenal; fire control apparatus, Frankford Arsenal; artillery ammunition, Picatinny and Frankford Arsenals; tanks and tractors, Rock Island Arsenal; proof, Aberdeen Proving Ground, Rock Island Arsenal, Frankford Arsenal, Picatinny Arsenal, and Springfield Armory.

These arsenals are an extremely important part of our preparedness program, for it is through them mainly that the art of munitions design and manufacture is perpetuated. They are to war munitions production what the Regular Army is to war manpower.

7. Storage and Issue System

The policy of the Ordnance Department in the matter of storage is as follows:

Stocks of munitions are divided into two main classes—

(1) Ammunition and components, including powder, high explosives, nitrate, etc.

(2) General supplies, including guns, tanks, tractors, small arms, machine guns, etc.

Ammunition reserves must be located with reference to probable areas of active operation, since ammunition is consumed primarily where troops *fight*. Reserves of general supplies, on the other hand, must be located with reference to probable mobilization points, since these supplies are needed where troops are *mobilized and equipped*. Furthermore, the maintenance of ammunition after issue to troops is negligible, whereas the maintenance of guns, tractors, tanks, etc., in the hands of troops presents about the same problem as confronts the automobile manufacturer and is solved in the same way; i. e., through "service stations" and service organizations. The policy with regard to each of these two classes of Ordnance material will be indicated separately.

(1) Ammunition and components:

The approved policy for the storage of this material contemplates the distribution of reserve ammunition and components, at strategic points.

This policy is based on the following:

(a) Maximum utilization of permanent storage facilities constructed during the War, consistent with safety regulations and having due regard to exposure to hostile operations.

(b) Location of sufficient ammunition to serve as a reserve for the West Coast at the nearest point at which the North, Central, and Southern sections of the Coast can be reached without relying on coast-line railroads. The storage facilities for this ammunition which have been constructed at Ogden Arsenal would also be important as a regulating station in the event of war to absorb fluctuations in the flow of ammunition from the East.

(c) Location of balance (main reserve), except high explosives, at central points in the interior of the country with excellent rail facilities from which, in time of war, distribution in any direction can be made. All loaded ammunition and components for the main reserve are to be stored at Savanna Proving Ground, only inert components being stored at Columbus and New Cumberland General Reserve Depots.

(d) Location of main reserve of bulk high explosives at Fort Wingate in a very sparsely settled territory having an exceptionally favorable climate for the purpose.

(2) General supplies:

The approved policy for the storage of general supplies contemplates the distribution of reserve supplies as follows:

Artillery matériel with all pertaining equipment, except fire control instruments, at Rock Island Arsenal, Erie Ordnance Reserve Depot, and the Aberdeen Proving Ground.

All artillery fire control optical instruments at Frankford Arsenal.

37-mm. guns, trench mortars, machine guns, and small arms at Rock Island Arsenal, Springfield Armory, and Raritan Arsenal.

All tanks at Rock Island Arsenal.

The controlling factors considered in choosing the storage points for the reserve supplies were adequate shop facilities and location which would allow prompt distribution in case of an emergency. All establishments storing reserve material have shop facilities for proper overhaul, alteration, and maintenance of material in storage, which is of great advantage from the standpoint of economy.

8. Munitions Policy

As already stated, the most important step for sound munitions preparedness is the development of a munitions policy by the Executive Department of the Government which has the continuing support of Congress.

As pointed out, it is the duty of the Ordnance Department to strive to be prepared to supply the Army with munitions of satisfactory quality and quantity. To accomplish this objective requires: first, a quality program which will keep us abreast of the times and apply to our munitions designs the reasonably latest developments in chemistry, metallurgy, and engineering; and second, a quantity program which requires that we keep on hand and in serviceable condition sufficient stocks to supply our probable armies until new production is adequate to meet demand.

(1) Quality Policy.

The quality program has always been part of the un-

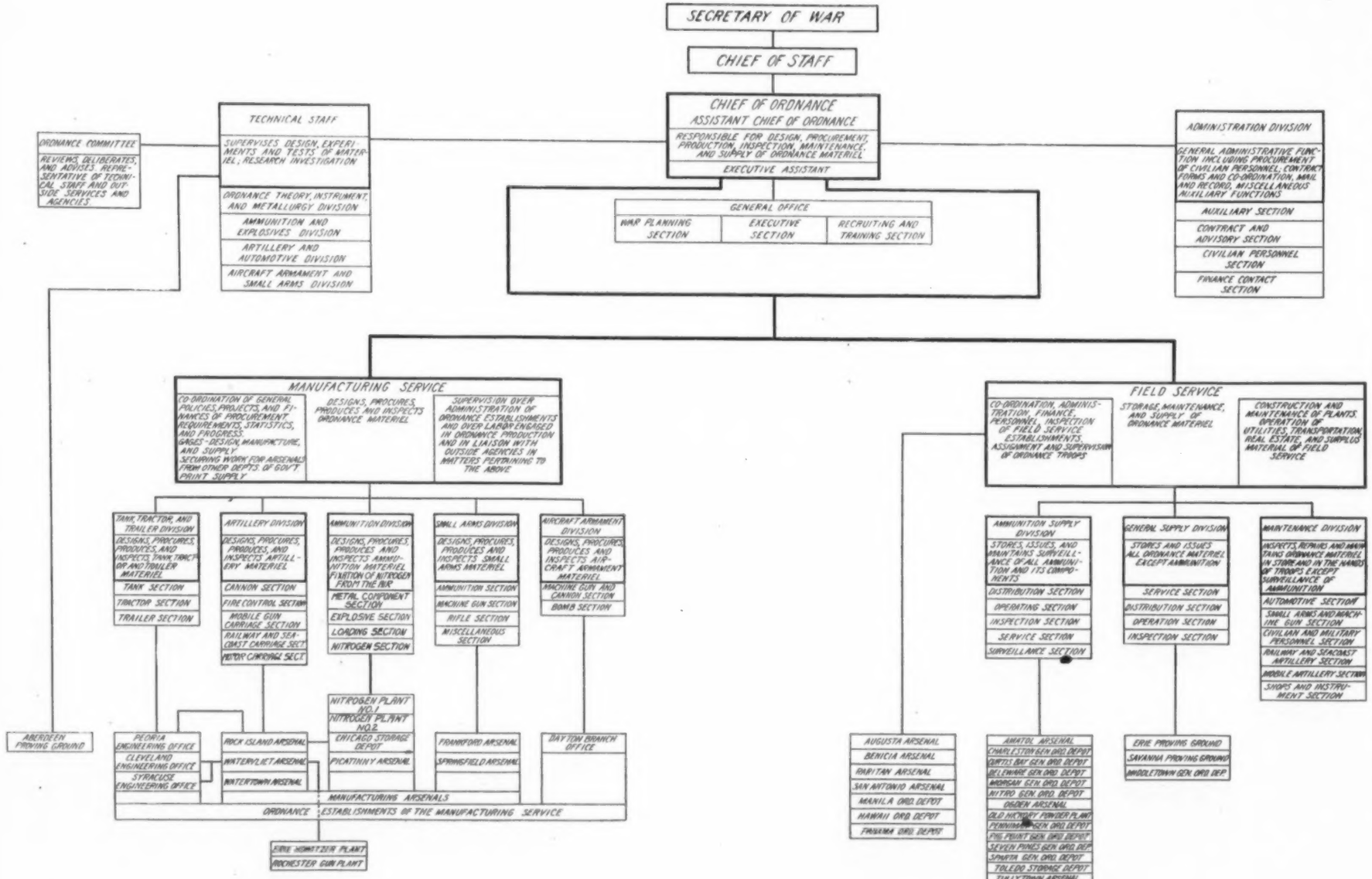

SECRETARY OF WAR
CHIEF OF STAFF
CHIEF OF ORDNANCE
ASSISTANT CHIEF OF ORDNANCE
RESPONSIBLE FOR DESIGN, PROCUREMENT, PRODUCTION, INSPECTION, MAINTENANCE, AND SUPPLY OF ORDNANCE MATERIEL
EXECUTIVE ASSISTANT
ORDNANCE COMMITTEE
REVIEWS, DELIBERATES, AND ADVISES. REPRESENTATIVE OF TECHNICAL STAFF AND OUTSIDE SERVICES AND AGENCIES
TECHNICAL STAFF
SUPERVISES DESIGN, EXPERIMENTS AND TESTS OF MATERIEL; RESEARCH INVESTIGATION
ORDNANCE THEORY, INSTRUMENT, AND METALLURGY DIVISION
AMMUNITION AND EXPLOSIVES DIVISION
ARTILLERY AND AUTOMOTIVE DIVISION
AIRCRAFT ARMAMENT AND SMALL ARMS DIVISION
GENERAL OFFICE
WAR PLANNING SECTION
EXECUTIVE SECTION
RECRUITING AND TRAINING SECTION
ADMINISTRATION DIVISION
GENERAL ADMINISTRATIVE FUNCTION INCLUDING PROCUREMENT OF CIVILIAN PERSONNEL, CONTRACT FORMS AND CO-ORDINATION, MAIL AND RECORD, MISCELLANEOUS AUXILIARY FUNCTIONS
AUXILIARY SECTION
CONTRACT AND ADVISORY SECTION
CIVILIAN PERSONNEL SECTION
FINANCE CONTACT SECTION
MANUFACTURING SERVICE
CO-ORDINATION OF GENERAL POLICIES, PROJECTS, AND FINANCES OF PROCUREMENT REQUIREMENTS, STATISTICS, AND PROGRESS. GAGES - DESIGN, MANUFACTURE, AND SUPPLY. SECURING WORK FOR ARSENALS FROM OTHER DEPTS. OF GOVT. PRINT SUPPLY
DESIGNS, PROCURES, PRODUCES AND INSPECTS ORDNANCE MATERIEL
SUPERVISION OVER ADMINISTRATION OF ORDNANCE ESTABLISHMENTS AND OVER LABOR ENGAGED IN ORDNANCE PRODUCTION AND IN LIAISON WITH OUTSIDE AGENCIES IN MATTERS PERTAINING TO THE ABOVE
TANK, TRACTOR, AND TRAILER DIVISION
DESIGNS, PROCURES, PRODUCES, AND INSPECTS TANK, TRACTOR AND TRAILER MATERIEL
TANK SECTION
TRACTOR SECTION
TRAILER SECTION
ARTILLERY DIVISION
DESIGNS, PROCURES, PRODUCES, AND INSPECTS ARTILLERY MATERIEL
CANNON SECTION
FIRE CONTROL SECTION
MOBILE GUN CARRIAGE SECTION
RAILWAY AND SEACOAST CARRIAGE SECT.
MORTAR CARRIAGE SECT.
AMMUNITION DIVISION
DESIGNS, PROCURES, PRODUCES AND INSPECTS AMMUNITION MATERIEL
FIXATION OF NITROGEN FROM THE AIR
METAL COMPONENT SECTION
EXPLOSIVE SECTION
LOADING SECTION
NITROGEN SECTION
SMALL ARMS DIVISION
DESIGNS, PROCURES, PRODUCES AND INSPECTS SMALL ARMS MATERIEL
AMMUNITION SECTION
MACHINE GUN SECTION
RIFLE SECTION
MISCELLANEOUS SECTION
AIRCRAFT ARMAMENT DIVISION
DESIGNS, PROCURES, PRODUCES AND INSPECTS AIRCRAFT ARMAMENT MATERIEL
MACHINE GUN AND CANNON SECTION
BOMB SECTION
ABERDEEN PROVING GROUND
PEORIA ENGINEERING OFFICE
CLEVELAND ENGINEERING OFFICE
SYRACUSE ENGINEERING OFFICE
ROCK ISLAND ARSENAL
WATERVLIET ARSENAL
WATERTOWN ARSENAL
NITROGEN PLANT NO. 1
NITROGEN PLANT NO. 2
CHICAGO STORAGE DEPOT
PICATINNY ARSENAL
FRANKFORD ARSENAL
SPRINGFIELD ARSENAL
DAYTON BRANCH OFFICE
MANUFACTURING ARSENALS
ORDNANCE ESTABLISHMENTS OF THE MANUFACTURING SERVICE
ERIE HOMOGENEITE PLANT
ROCHESTER GUN PLANT
FIELD SERVICE
CO-ORDINATION, ADMINISTRATION, FINANCE, PERSONNEL, INSPECTION OF FIELD SERVICE ESTABLISHMENTS, ASSIGNMENT AND SUPERVISION OF ORDNANCE TROOPS
STORAGE, MAINTENANCE, AND SUPPLY OF ORDNANCE MATERIEL
CONSTRUCTION AND MAINTENANCE OF PLANTS. OPERATION OF UTILITIES, TRANSPORTATION, REAL ESTATE, AND SURPLUS MATERIAL OF FIELD SERVICE
AMMUNITION SUPPLY DIVISION
STORES, ISSUES, AND MAINTAINS SURVEILLANCE OF ALL AMMUNITION AND ITS COMPONENTS
DISTRIBUTION SECTION
OPERATING SECTION
INSPECTION SECTION
SERVICE SECTION
SURVEILLANCE SECTION
GENERAL SUPPLY DIVISION
STORES AND ISSUES ALL ORDNANCE MATERIEL EXCEPT AMMUNITION
SERVICE SECTION
DISTRIBUTION SECTION
OPERATION SECTION
INSPECTION SECTION
MAINTENANCE DIVISION
INSPECTS, REPAIRS AND MAINTAINS ORDNANCE MATERIEL IN STORE AND IN THE HANDS OF TROOPS EXCEPT SURVEILLANCE OF AMMUNITION
AUTOMOTIVE SECTION
SMALL ARMS AND MACHINE GUN SECTION
CIVILIAN AND MILITARY PERSONNEL SECTION
RAILWAY AND SEACOAST ARTILLERY SECTION
MOBILE ARTILLERY SECTION
SHOPS AND INSTRUMENT SECTION
AUGUSTA ARSENAL
BENICIA ARSENAL
RARITAN ARSENAL
SAN ANTONIO ARSENAL
MANILA ORD. DEPOT
HAWAII ORD. DEPOT
PANAMA ORD. DEPOT
AMATOL ARSENAL
CHARLESTON GEN. ORD. DEPOT
DUTCH BAY GEN. ORD. DEPOT
BELLEMEAD GEN. ORD. DEPOT
MIDWAY GEN. ORD. DEPOT
NITRO GEN. ORD. DEPOT
OGDEN ARSENAL
OLD HICKORY POWDER PLANT
PENNINGTON GEN. ORD. DEPOT
PRL POINT GEN. ORD. DEPOT
SEVEN PINES GEN. ORD. DEP.
SPARTA GEN. ORD. DEPOT
TOLEDO STORAGE DEPOT
TULLYTOWN ARSENAL
WINGATE GEN. ORD. DEPOT
WOODBURY GEN. ORD. DEPOT
ERIE PROVING GROUND
SAVANNA PROVING GROUND
MIDDLETOWN GEN. ORD. DEP.

Fig. 5. Organization of the Ordnance Department

written Military Policy of the United States, for the Ordnance Department has gone to Congress year after year for money for this purpose and has always received at least a part of its estimate. The great portion of our 1923 estimates are for development work, especially to put into designs the World War experience.

(2) Quantity policy.

Insofar as is known, the country has never had until recently a comprehensive military policy in the matter of quantity of army munitions that should be comprised in a reserve and that should be kept in serviceable condition for use, except, perhaps, in the case of munitions for coast defense purposes.

Practically every military authority now seems to be agreed that, with equal starts, new manpower can be supplied to the fighting front some twelve months ahead of new munitions. We know that, in the last war, the flow of American made munitions had hardly reached the front at armistice time or nineteen months after the start of war, and that our troops would have had practically no fighting material except that we were able to procure the same from the Allies.

It is not believed that this serious lag on the part of munitions was properly foreseen before the war or that it is generally appreciated even now. But it most certainly exists. And the inescapable conclusion, therefore, if we would have adequate preparedness, is that we must maintain sufficient reserve stocks of satisfactory munitions for our contemplated war army to supply it until our production is adequate.

(a) Replacement Program.

Fortunately as a result of the World War we have been left with large quantities of munitions—in most cases, and in so far as the major part of the units are concerned, adequate to meet our demands until new production is sufficient.

But unfortunately these stocks, even with the best of care, will not last indefinitely. Smokeless powder has an estimated life of only some fifteen years due to chemical deterioration, and it is not believed that we are justified at the present time in assigning a life to any of the chemicals in ammunition, or to the loaded ammunition which contains them, in excess of fifteen years. Time may prove that the life is longer, and periodic tests are under way to establish the life. To keep our ammunition stocks in serviceable condition requires, therefore, a replacement program.

But even though the stocks did have an indefinite life as is substantially true in the case of the metals which enter munitions, as for instance, in artillery guns and carriages, we would still be faced with the problem of supplying our armies with munitions of reasonably up-to-date designs. This country can certainly afford, and in time of war would be insistent upon, guns of as recent design as those available to our enemy. But if we do not keep our stocks reasonably up-to-date in design, and equal in quality to those available to our probable enemy, and if we depend upon war production for the incorporation of new developments, we must accept the fact that the first twenty to thirty months of war—during which time it would probably be decided—would have to be fought with old style guns. In other words, a replacement program is necessary to keep reserve stocks of guns in a proper state of design.

While it is not believed that serious question can be raised against the principle of a replacement program, it is believed that there can be very serious question raised as to the extent of such a program. We are now planning on retaining stocks of munitions as our war reserve in accordance with the General Staff instructions of October 13, 1921, to a value of some $1,000,000,000. Half of this, in value, is ammunition and half guns. Assuming even an average yearly replacement charge of 5 per cent on ammunition and 2½ per cent on guns, the total yearly replacement charge would be some $37,500,000, which is probably prohibitive. It is quite probable that the higher military authorities would not recommend that such a large reserve be replaced. Essential items might be selected for replacement in limited quantities. Furthermore, our present stocks are of reasonably recent manufacture and design and are at present quite equal to those available to any enemy. Improved designs are not yet available. It is not, therefore, in order to start a large replacement program at the present time. The necessity for inaugurating this replacement program in the future shall, however, be kept constantly in mind.

The Limitations of Arms Conference, in the matter of a Navy, established a minimum naval munitions reserve—or a certain number of fighting ships plus guns and ammunition—established a time when replacements would begin—or at end of ten years, and established a life for such ships, after which life replacement was in order—or twenty years.

(b) Commercial Manufacture.

It is to be noted that one of our greatest assets in expediting production in time of war is knowledge on the part of the arsenals and of commercial companies in the art of doing the particular work desired. This is really of vital importance in the task of mobilizing industry. Fortunately a great portion of our munitions work can be quite easily grasped by commercial companies. But other work which is essentially military cannot be readily undertaken. Examples are gun manufacture, fire control apparatus manufacture, smokeless powder manufacture, fuze manufacture, and assembly of ammunition. Pending the start of a replacement program, it is believed, therefore, that sufficient manufacture should be provided for not only to keep the arsenals going on the smallest scale that will keep alive the art, but also to insure some commercial activity. This activity is to the Ordnance Department what the National Guard and Reserve Army are to manpower.

9. Conclusion

Such, in outline, is the Ordnance Problem. The measure of success in its solution we may achieve in the future will be dependent upon many factors, only a part of which are directly controllable by the Ordnance Department. The Department can broaden its influence, however, by frankly presenting its case to the War Department and to Congress when asking for appropriations and by taking the American public into its confidence insofar as this may be consistent with the preservation of military secrets.

It must also enlist the support of that part of American industry which will be directed to the production of munitions in the event of an emergency. The total output of all our arsenals, working to full capacity, is less than five per cent of what our requirements would be if our maximum effort was called for.

We must depend upon American industry to carry the war burden, and the active support and assistance of our industrial agencies in time of peace will be of the most invaluable help in the event of war.

Finally, it may be pointed out that there is one and only one criterion by which to measure our success—the service we give the combatant branches. It is our duty to give *them what they need, where they need it, when they need it, and in the amounts they need.*

The Ordnance Training Program

By

T. J. HAYES

Member A. O. A.

OTHER articles in this number of ARMY ORDNANCE present in detail the operation of several components of the Ordnance Educational plan; accordingly this article will only deal with the general plan of training the personnel of the permanent establishment, with a more detailed discussion of Reserve training.

Education and Training of Ordnance Officers

Prior to the entrance of this country into the World War preliminary steps had been taken toward the revision of the courses of instruction at the Ordnance School of Application at the Sandy Hook Proving Ground and at the Ordnance School of Technology at the Watertown Arsenal. It had become evident that the existing system of education and professional training, while it had accomplished most excellent results with a small number of officers, was in the need of systematizing and extension. It had not been possible to give all officers coming into the Department the benefit of the Schools maintained and little opportunity was afforded to secure the benefit of training in agencies outside of the Department itself. Moreover it was very exceptional for officers of other branches of the Army to come into intimate contact with the Ordnance Department and observe its operation from the inside.

The proposed scheme of training, necessarily postponed by the entrance of this country into the war, had for its ultimate aims the following:

a. Thorough education and training for every Ordnance Officer.

b. An exchange of ideas, and a closer cooperation with the Line of the Army, other staff departments, the Navy and the civilian world.

c. Opportunity for specialization on the part of those Ordnance Officers so desiring and possessing the necessary qualifications therefor.

To secure these results it was proposed to make use of the following agencies:

a. A school or schools covering, in general, the same ground as the schools at Sandy Hook and Watertown.

b. The General and Special Service Schools, particularly—

Army War College	Field Artillery School
General Staff School	Infantry School
School of the Line	Engineer School
Coast Artillery School	

and other Special Service Schools when conditions would permit.

c. Civilian technical schools and colleges.

d. Commercial and industrial organizations and private manufacturing plants.

The use intended to be made of these agencies will be explained in detail:

The Ordnance Department Schools: While recognizing that many officers of the Department had not as yet had the benefit of these courses of instruction and realizing the advisability of granting them the opportunity to avail themselves of this professional education at the earliest possible time, yet it was intended that these schools should ultimately become an agency for training officers of the line. Such a plan would serve two very useful purposes:

a. It would afford the best means for selecting officers best qualified for service in the Ordnance Department.

b. It would insure the presence at all times in the line of the Army of officers who are familiar with Ordnance materiel, its design and manufacture, who would have numerous personal acquaintances in the Department and by reason thereof would constitute an agency for liaison between the Department and the remainder of the Army.

Other Service Schools: These schools should be of the greatest value in bringing the Department in close touch with the Army. The object to be sought is not only the acquisition of the knowledge and ideas of other branches of the Army and conversely the transmission of Ordnance knowledge and ideas to others but, what is of great importance, the assurance of many points of contact with resulting mutual understanding.

Civilian Technical Schools: It was felt that the Department did not have the desired contact with the current development of the engineering and scientific world and that Ordnance Officers had not had the opportunity of specializing in particular phases of Ordnance work. It was realized that these educational institutions had a logical position in the Ordnance educational plan, affording a means whereby officers of special talent could acquire the latest and most advanced knowledge available in their chosen specialties; it was also realized that only by a continuous, effective liaison could members of the staffs of these institutions come into contact with the Department and acquire a knowledge of such problems with which they are fitted to cope and with which they logically must be concerned in any great emergency involving mobilization of the country.

Commercial Organizations: In time of peace the principal developments in manufacturing methods and processes are made by commercial organizations; furthermore, it is these organizations which in time of war must be counted on to produce the great bulk of the munitions required. It is evident that the detailing of specially qualified officers to manufacturing plants and industrial organizations will insure a transmission of valuable ideas to the Department, and in addition to the knowledge acquired by the officers, tending to better fit them for Ordnance work, will play no little part in bringing these organizations in closer touch with the Ordnance Department and Ordnance problems.

Post war: Such was the plan and with a few minor changes, this is the plan in effect today, which a very brief summary will disclose:

a. The Ordnance School, under the direct supervision and control of the Chief of Ordnance provides the agency for the technical education of Ordnance Officers. It is primarily a training school for Ordnance Officers rather than for Line officers as originally planned. The large increase in Ordnance activities and the necessity of a greatly enlarged Ordnance commissioned personnel has necessitated the acceptance into the Department of a large number of officers who have not had the advantage of instruction at Ordnance Schools. Consequently every effort has been made to provide for the technical education of these officers as early as

possible, the lack of funds thus limiting the number of line officers who can be selected.

b. During the coming year the Ordnance Department will be represented by students at all the service schools enumerated, the courses of instruction varying from the basic military courses for those officers who demonstrate the need of military instruction to courses at the General Service Schools at Fort Leavenworth and the Army War College.

c. During the coming school year postgraduate courses for Ordnance officers will be provided at the Massachusetts Institute of Technology and at the University of Chicago. The courses at the former will include Chemical Engineering, Automotive Engineering, and Mechanical Engineering. At the latter a course in ballistics will be conducted by Professor F. R. Moulton whose studies in the science of exterior ballistics during the war resulted in such great advances in the understanding of this science.

A Necessary Adjunct to Training

d. Student officers will be detailed at several of the large industrial plants this year. The advantages foreseen of this contact have been realized and as the number of graduates of the Ordnance School increases, and resulting practical experience indicates the particular work for which each officer is fitted, the number of officers fitted and available for duty at the various plants will increase.

Education and Training of Ordnance Enlisted Personnel

In order that the storage, supply and maintenance duties of the Ordnance Department may function efficiently in the field, it is essential that the enlisted personnel be highly trained as individuals and that the organizations to which they belong be so trained as a unit that they may be able to take the field and perform successfully the duties for which the organization is designated. To insure this result four separate training phases are necessary:

a. Basic military training,
b. General education and vocational training,
c. Specialist training,
d. Organization training.

Military training for the Ordnance soldier is an essential part of his education. It is not necessary that he receive the intensive training under arms that the line soldier receives nor is it desirable that too much emphasis be paid to the drill at the expense of trades training, yet he must first of all be a soldier with proper discipline and a thorough understanding of his military duties, responsibilities and privileges. The first step to attain this understanding is the intensive training which a recruit receives at his first military station. In time of peace this must be given in the organization to which he is assigned, for the abolition of recruit depots and training centers and the present plan of localized recruiting for organizations introduces the soldier to his organization without prior elementary military instruction. It thus makes the organization itself the training place for recruits and places upon the commanding officer the responsibility for elementary military as well as organizational training. In time of war these conditions must change and the duties of commanding officers will consist largely of welding together partially trained men into an efficient organization. At this time the duties of the Ordnance Specialists School and such other training schools as may be established will include elementary military as well as trades training.

Post Schools are maintained for the education and vocational training of enlisted men. As far as general education is concerned, courses are divided into two classes:

a. Primary education of illiterate and non-English speaking recruits.
b. More advanced work in general education for those enlisted men who volunteer for such instruction or who may need it in connection with or preparatory to vocational courses.

The primary objects of the vocational training are:

a. To give instruction to that personnel of an organization the duties of whom require occupational skill similar to that required in the vocations taught.
b. In time of peace to provide school plants and to develop teaching technique which will be suitable and available in war for the training of technicians and specialists.
c. To afford enlisted men who volunteer, opportunities for instruction in vocations which will improve their condition in civil life after leaving the Army.

The Education and Recreation Officer at each post functions as officer in charge of Post Schools. While the actual operation of the school is in the hands of the officer in charge, yet The Adjutant General of the Army is charged with the development and production of methods of instruction for general education and the manuals and aids to be used therein, and the Chiefs of Branches are charged with harmonizing, developing and standardizing courses in certain assigned subjects, incuding the methods of instruction and the preparation of necessary manuals and aids. In addition to the specialties pertaining to a branch itself, certain subjects common to two or more branches are assigned to a single branch. For example, the Ordnance Department is assigned courses for instrument repairmen, machinists, foundry men and pattern makers in addition to the courses based purely on Ordnance Specialties.

The Ordnance Department is particularly fortunate in its ability to provide this vocational training. At the various Ordnance establishments are located the proper types of companies whose normal duties in the field largely parallel or are covered by existing local activities. Even where the duties are not actually paralleled it is found that the existing shops, warehouses and magazines afford vocational training possibilities which obviate the establishment of separate training schools thereat. Considering the Ordnance organization in the field, with the line of the Army at Special Service Schools of the Line, at Camps, etc., it is found that the normal activities of the companies constitute themselves vocational training courses and require little supplementing to afford the desired training.

It is recognized, however, that a strong centralized Special Service School is necessary to develop the trained specialists and to relieve organization commanders from the burden of developing specialists. In the organization the normal military duties require practically the whole time of the enlisted men and it would not be practicable to attempt to build trained skilled specialists from raw material. That is a function of the Special Service School. And while it is admitted that the organization is equipped to give trades training on the actual matériel or in the actual work which the individuals are to follow, yet thorough, intelligent, general training can best be given at a school

fitted and equipped for training, with skilled instructors, and where the whole atmosphere is one of training rather than of performance of routine military duties. Furthermore it is necessary to retain in operation a school which in time of emergency can be quickly expanded.

The Ordnance Specialists School, Raritan Arsenal, N. J., under the direct supervision and control of the Chief of Ordnance operate primarily for the instruction of Ordnance specialists and secondarily for the instruction of enlisted men of other branches. From every Ordnance organization about ten per cent of the authorized personnel will be selected for training each year. Such a plan resulting in a flow of trained specialists to the line and to Ordnance companies will result in a marked improvement in the personnel together with increased efficiency of the organizations as a whole.

The Ordnance Specialists Schools affords the means for rapid expansion of the training program in time of war. Its facilities then would be fully employed and, operating at full capacity, trained graduates would come forth in sufficient numbers to provide the necessary organizations.

In considering organizational training it is necessary to briefly consider the various types of organizations and their locations. Ordnance Maintenance Companies are located at West Point, N. Y.; Fort Bliss, Texas; Fort Benning, Ga.; Fort Sill, Okla., with the 1st, 2nd, 3rd and Cavalry Divisions and at Watertown Arsenal, Springfield Armory, Watervliet Arsenal and Frankford Arsenal. Ordnance Heavy Maintenance Companies are located at Camp Bragg, S. C., at the Tank School, Franklin Cantonment, Md., at Camp Eustis, Va., and at Rock Island Arsenal. Ammunition Companies are located at Curtis Bay, Md.; Raritan Arsenal, N. J.; Picatinny Arsenal, N. J.; Pig Point, Va., and Pedricktown, N. J., all ammunition storage points. Depot companies are located at San Antonio, Benicia and Augusta Arsenals, Savanna and Erie Proving Grounds, and at Fort Bliss, Tex., all storage depots. The Proving Ground Company and the Headquarters Company are located at Aberdeen Proving Ground. The Training Company is located at Raritan Arsenal.

It is thus seen that the proper type of company is located at each Ordnance establishment and that the companies on duty with the line of the Army, or at line camps and stations, are the proper types to perform the supply and maintenance duties to be found there. The organizational training of these latter companies presents no difficulties inasmuch as the duties normally performed are very similar to those to be performed in the field in war time.

The large number of companies at Ordnance establishments is accounted for as follows:

a. In time of peace the personnel can render valuable service performing current work in direct line with the war time duties. Accordingly there is a direct return to the government.

b. It permits of holding intact trained organizations for use in any emergency. As an example, all the Ordnance Maintenance Companies stationed at manufacturing arsenals are on duty at training camps this summer, performing necessary supply and maintenance duties and themselves receiving field training.

In order to insure that proper organizational training is carried out in the Ordnance Companies located at Ordnance establishments the Chief of Ordnance has prescribed the following:

a. No enlisted man shall be assigned permanently to any duty which is not strictly in the same category which he must perform in the field.

b. The number of men for guard, fire protection, and similar duties must be held to a minimum and such details must be by rotation and so arranged as not to interfere with proper organizational training.

c. The organization must be so trained that it can take the field at short notice and be able to perform efficiently the duties properly assigned to it. To this end training schedules must be prepared and instruction carried on which will attain this end. This training is to be carried on under the general supervision of Ordnance Field Service which by necessary inspections can determine the status of training at all times.

Core Making at the Ordnance School

d. It shall be the policy of the Ordnance Department to utilize Ordnance organizations, or detachments therefrom, to the fullest extent at the summer training camps and thus acquire valuable experience as well as render service to the line.

It is believed that the agencies herein described will insure trained and educated personnel welded together into efficient organizations.

Training of Ordnance Reserve Officers

The whole question of personnel preparedness can be stated in a few words:

Careful selection.
Intelligent assignment.
Adequate training.

Selection of Ordnance Reserve Officers is made from one of the following classes:

a. Those who served in the World War either as officers, enlisted men, or civilians and who demonstrated their fitness for commission.

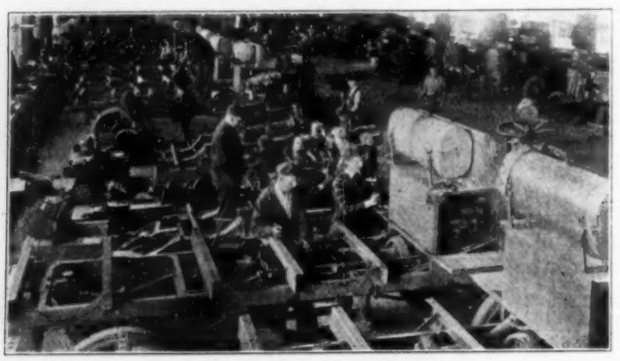
b. Reserve Officers' Training Corps graduates.

c. Commissioned officers of the National Guard.

d. Those persons having not less than two years practical experience in professions or occupations which fit them for performance of duties pertaining to the Ordnance Department in time of emergency.

As time goes on the numbers of trained officers produced by the war will diminish and it will be necessary to offset this loss by selection from other sources. A most promising field exists at our educational institutions where Reserve Officers Training Corps Units each year train and pass on into the Reserve Corps, the finest type of young educated Americans. The Ordnance Department has established units at nine of the leading institutions of the country and it is planned to extend this number gradually as suitably trained commissioned personnel can be spared from other activities.

Another large source of supply is the class of people in civil life whose work to a great extent fits them for their contemplated service. This class can be appointed largely on a consideration of their professional or occupational standing and experience. This professional experience, together with the ability to adapt such knowledge to the requirements of military experience is a most valuable asset to the Ordnance Department.



Raritan Arsenal. Truck Repair Shop

There are three general ways of determining the qualifications of an applicant for appointment:

a. Examination of his record.
b. Attendance at a course of instruction.
c. Personal examination.

The first method applies primarily to those who served during the World War; the second applies to graduates of training camps and R. O. T. C. units; the third applies to all other persons, the examination being only of sufficient scope to determine whether the applicant possesses "general knowledge of a branch of engineering or other profession or occupation qualifying for duty in the Ordnance Officers' Reserve Corps."

It is evident from a consideration of these sources that the Ordnance Reserve Officer may be a young man just graduating from college or he may be a middle-aged business man; he may be a scientist, an engineer, an executive or a lawyer. Whatever he may be, it is essential that he be assigned to a duty for which he is best qualified by education and experience and to the class of work for which he is best adapted.

For purposes of assignment Ordnance Reserve Officers are divided into three general groups as follows:

a. General Assignment (G. A.) Group: Those reserved by the War Department for assignment to activities and duties with which the Chief of Ordnance is not concerned.
b. Branch Assignment (B. A.) Group: Those selected by the Chief of Ordnance for assignment to purely Ordnance activities.
c. Territorial Assignment (T. A.) Group: Those released to Corps Area and Department Commanders for assignment to tactical organizations.

With the G. A. Group we are not concerned since the numbers are limited and selection has been made by reason of some peculiar fitness.

Officers of the B. A. Group are assigned in accordance with their experience and fitness to one of the following:

a. Office of the Chief of Ordnance.
b. Ordnance Manufacturing or Field Service establishments.
c. Ordnance District Offices.

When so assigned officers are designated for a specific duty and position, each office, establishment or district having a table of organization which designates the duties and the appropriate rank for each officer detailed therein.

Officers of the T. A. Group are assigned to duty with Divisional, Corps or Army Headquarters or with Ordnance Companies serving in these therewith. The greater part of the officers in this group will be assigned to Ordnance Maintenance, Heavy Maintenance, Depot, and Ammunition Companies and a much smaller number to the various headquarters. Here also assignment must be to a specific position. For example, the assignment to a certain Maintenance Company is not sufficient. It is necessary that the assignment be to a specific section, such as the Artillery or the Automotive Section, to the end that no misunderstanding can arise as to the exact duties which the officer must be qualified for and in which he must be trained.

The activities of the Ordnance Department cover such a vast field that the question of training specialists is a most difficult one. Were it not that selection has largely been made from those whose occupations parallel closely Ordnance activities the training difficulties could be insurmountable.

The War Department has established Army Correspondence courses, the object of which is the military training and education by correspondence school methods of the personnel of the Officers and Enlisted Reserve Corps, and civilians who may volunteer for such courses. The plan prescribed that the scope of instruction for each branch should be as follows:

Course A.—Elementary tactics and technique covering subjects embraced in the basic course of the Special Service School of the Branch.
Course B.—Tactics and technique covering subjects embraced in the company, troop and battery officers' course of the Special Service School of the branch.
Course C.—Advanced tactics and technique covering subjects embraced in the field officers' course given by the Special Service School of the branch.
Course D.—Combined course for all arms based on the work given by the school of the line.
Course E.—Special subjects for personnel reserved for Branch Assignment.

It is evident that while courses A, B, C, and D are admirably adapted for the instruction of Reserve Officers of the Line, they are not adapted for Ordnance instruction. Accordingly, an alternative plan was submitted by the Ordnance Office which provides the following courses:

Course A.—A basic fundamental course of instruction, largely military, embracing organization, administration, military law customs of the service, finance and property accountability, military hygiene, gas defense, map reading and other subjects of the same general nature. It is planned that this course be taken by all Ordnance Reserve Officers unless exempted therefrom by reason of previous experience and qualification.
Course B.—A course of instruction for officers of the T. A. Group covering the general duties of Ordnance Field Service and its relation to the other branches of the Service, and the detailed duties of each type of Ordnance Company, including a study of the working equipment of the company and the materiel to be supplied and maintained.
Course C.—A brief course for the officers at Division, Corps and Army headquarters.

Correspondence courses are conducted by the Corps Area Correspondence Schools and enrollment is entirely voluntary. Of the Ordnance courses, only Course A will be given this year because of the non-availability of texts, handbooks and training regulations. Training regulations are being written covering every type of Ordnance matériel and the detailed duties of each type of Ordnance Company but the program is so extensive that another year must elapse before publication can be expected.

It is seen that the training described is, with the exception of the basic course, adapted only for the Territorial

Assignment Group. The three courses, supplemented by training camps where practical training may be had by assignment or attachment to Ordnance organizations, and by training periods with Corps Area and other headquarters where Ordnance personnel is assigned, will furnish the Reserve Officer of this group the knowledge and experience which will enable him to properly understand his duties and proceed with them intelligently when called to active duty in time of emergency.

The training of the Branch Assignment Group presents much greater difficulties. A reserve officer may be assigned to research work, or design, or inspection, or production; he may be concerned with artillery, or ammunition, or tractors; he may be on storage, or supply, or maintenance; his work may be entirely administrative or it may be of a technical or engineering nature. It is readily evident that training cannot be accomplished by correspondence school methods and that the Ordnance Department must seek Reserve Officers whose professions or occupations largely qualify them for Ordnance Service and then endeavor to afford such training as practicable. This can be accomplished as follows:

a. By encouraging frequent visits to the Office of the Chief of Ordnance and to the various Ordnance establishments and extending all facilities towards helping Reserve Officers become familiar with the organization, the work being carried on, and the detailed duties of the positions for which designated.

b. By furnishing officers with monographs, lectures, pamphlets, handbooks, descriptive material, engineering, and scientific data, and such other pertinent information as may be necessary to keep each officer informed of the latest developments in the particular line of work for which he is designated.

c. By furnishing officers assigned to the Ordnance District Offices concrete problems to be solved, bearing upon the work to which assigned in war time.

d. By calling reserve officers to active duty and assigning them to the duties which they may expect to be assigned in time of war.

This latter furnishes the real training desired and deemed necessary. Unfortunately two factors enter, over which the Chief of Ordnance has no control:

a. The number of officers who can be called to active duty each year depends upon the funds appropriated by Congress for pay and mileage.

b. Reserve Officers cannot be called to active duty for a period sufficient to give the training desired, except by their own consent.

The difficulties to be surmounted in giving the large body of Ordnance Reserve Officers the training which will bridge the gap between their civilian professions and their Ordnance duties are many and complex; only by the closest cooperation on the part of all concerned, regular and reservist, with a correct understanding of the training necessary for each position, and a willingness to make personal sacrifices by taking part in the annual training period, can these difficulties be overcome and the question of personnel preparedness solved.

Training Ordnance Officers

By

T. C. DICKSON
Member A. O. A.

MAJOR General William Crozier, U. S. Army, Retired, when Chief of Ordnance, recognized that the knowledge required for the design, manufacture, inspection, maintenance and issue of Ordnance could be given more economically to officers of the Ordnance Department by systematic training than by the method theretofore used since the Ordnance Department was created by law, which consisted in the acquiring of the knowledge when the performance of duties assigned necessitated that action. In about 1904 a series of problems which had been solved in connection with the designing of guns, carriages and projectiles were prepared and young officers of the Ordnance Department on duty at the Sandy Hook Proving Ground as Assistant Proof Officers were encouraged to master the basic principles used therein in the time not required for their other duties. Subsequently, Electricity, Chemistry of Powders and Explosives, Differential Equations, Work on Machines and Power Appliances was added, and as many of the officers entering the Department as could be spared were assigned, with no other duty, as student officers for a period of one year in which to devote themselves to the courses, which was the beginning of the Ordnance School.

In about 1904 the Commanding Officers of the principal manufacturing arsenals prepared programs of practical work in shops, and young officers upon their entry into the Ordnance Department were encouraged to complete as much of the programs as their other duties would permit. The shortage of officers prevented this method of instruction proving satisfactory, and as the variety of work carried on at the Watertown Arsenal offered the broadest field of instruction, and as the then Commanding Officer took a keen interest in the school work, all practical shop and laboratory work was concentrated at that place and officers were assigned to the school for a period of one year.

The Ordnance School of Application at the Sandy Hook Proving Ground and the Ordnance School of Technology at the Watertown Arsenal continued in operation until the summer of 1917, when they were suspended during the World War. In the summer of 1919 the instruction of officers entering the Ordnance Department was resumed, the Ordnance School of Application being reestablished at the Aberdeen Proving Ground. To obtain the advantages resulting from the association of officers with other students in civilian technical institutions and the economy resulting from utilizing existing facilities, the Ordnance School of Application was transferred to the Watertown Arsenal in the summer of 1921, consolidated with the Ordnance School of Technology, new courses of instruction added, which formed the Ordnance School. At the same time, arrangements were made with the Massachusetts Institute of Tech-

nology to give the courses of instruction formerly included in the Ordnance School of Application.

The Ordnance School now includes the following courses, namely:

Course I.
Course II.
Post-graduate Courses at educational institutions.
Post-graduate and Research Work at the Watertown Arsenal and in commercial manufacturing plants.
Course in Administration and System of Management.
Courses for Officers of the Reserve Corps and National Guard.
Special Courses.

The object of the courses is to prepare officers of the Ordnance Department for the efficient performance of their duties.

Course I, given at the Massachusetts Institute of Technology, covers the various basic principles in science and engineering required for Ordnance work, but the instruction is eminently practicable as the principles are learned by the solution by students of the same problems as the designers of Ordnance have made, by the study of electricity consisting largely of the operation and testing of the principal electrical instruments and machines used in Ordnance and in commercial plants, and by the chemical study of powders and explosives consisting principally of laboratory work. The studies included in Course I are Differential Equations, Ordnance Engineering, Theory of Elasticity, Chemistry of Powders and Explosives, Electricity, Heat Engineering, Power Laboratory and Preliminary Machine Tool Work. This course normally begins on July 5th and ends the last of June. Fig. 1 shows officers working in Electrical Laboratory.

Course II includes Pyrometry, Metallurgical Chemistry, Metallography, Testing Materials, Gas Engines, Shop Management, Field Service, Pattern Making, Foundry Work, including Molding and Melting of Metals, Machine Shop Work, including Operation of Machines, Assembling, Forging and Blacksmithing. The first four subjects are taught in the arsenal laboratories; the Gas Engine Course is given at the Massachusetts Institute of Technology; the courses in Machine Shop and Foundry, given at the arsenal, require student officers to personally do work on each of the various types of machines and of the various processes carried on in the foundry; this work is principally manual, supplemented by study. Figs. 2 and 3 show officers working in the foundry. Fig. 4 shows officers erecting a carriage and Fig. 5 shows officers forging an ingot with an 800-ton press. Students do not work for a sufficient length of time on any one type of machine or one process to become technically skillful, but do work on each for the length of time necessary to obtain a clear conception of the care and skill required, of the time taken to perform an operation, the best type of machine on which each class of work can be performed, and the gaining of such other knowledge as a supervisor must possess. The Course in Gas Engines includes the theoretical calculations of the power obtainable from a given design, the dismantling and study of the design, the operation, the making of various tests and the finding of the cause of troubles to be anticipated with the different types of Gas Engines supplied by the Ordnance Department. The courses in the foundry and in the laboratory impart a clear knowledge of the various kinds and grades of metals used in Ordnance, a practical knowledge of making chemical, physical and microphotographic tests and give both a theoretical and practical knowledge of the annealing and heat treating of steel.

Student officers working with and among civilian employees become acquainted with the latter, learn their viewpoint and obtain the knowledge essential to a supervisor that workmen are human beings and that if some of them had had the same educational advantages as the student officers they would unquestionably have proved equally qualified for officers' duties. This knowledge is essential for an officer who is to direct civilian employees. Course II begins the middle of July and ends June 30th.

Briefly, Course I has for its object the assimilation by Ordnance officers of the basic principles of engineering and science used in the design and manufacture of Ordnance and their practical application with correctness and facility, while Course II has for its prime object the qualifying of student officers for supervisory positions in manufacturing plants.

Course I and Course II are the basic courses for fitting young officers to competently perform their duties in the Ordnance Department. The limited time available for those two courses, namely two years, prevents the inclu-

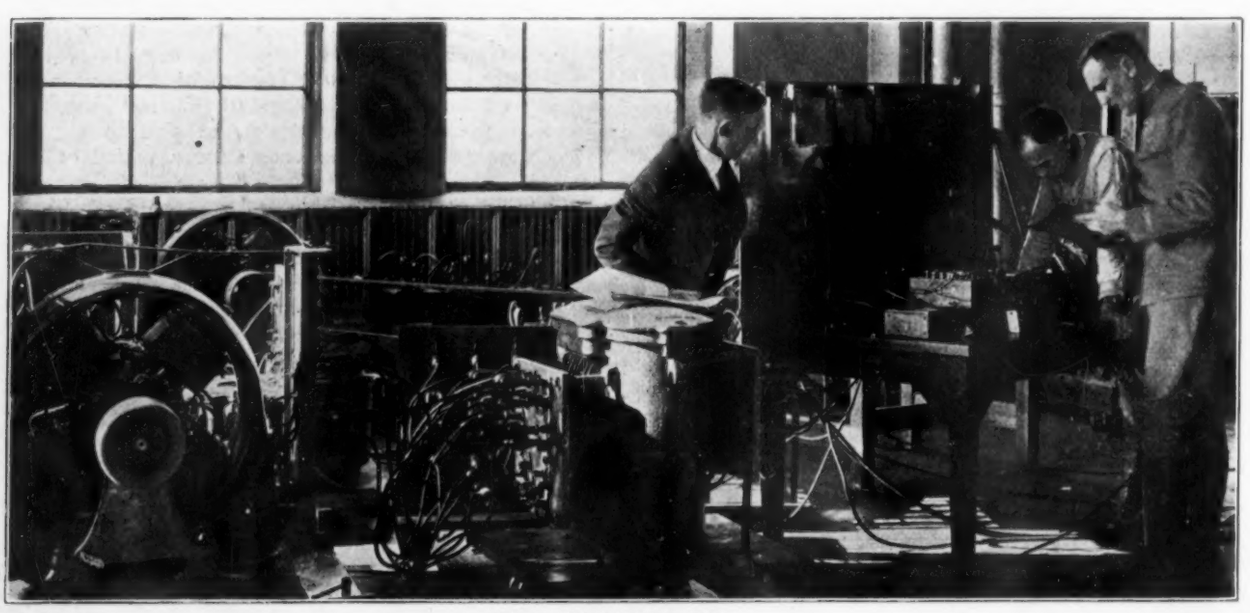


Fig. 1. Electrical Laboratory.

sion of a number of studies that are necessary for Ordnance officers specializing in different classes of work, and which have therefore been included in other courses to be taken subsequently. The continuation of a young officer for too long a period as a student tends to the acquirement of the academic point of view. It is the policy of the Chief of

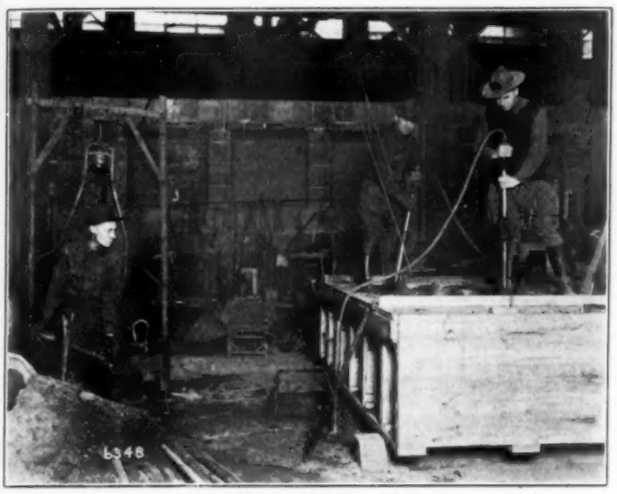


Fig. 2. Molding.

Ordnance that, upon the completion of the two years in the Ordnance School, young officers shall engage in actual production. Experience shows that each officer engaged in production from time to time finds principles and processes of which more knowledge would be of assistance, and after an officer has been engaged in production for at least three years, Post-graduate Courses either at an educational institution, in the laboratories at the Watertown Arsenal, or in private manufacturing plants, have been provided, and the studies to be pursued or work to be done are determined as far as possible by the principles or processes concerning which the individual has found from experience further knowledge would materially benefit him. The Post-graduate or Special Course for each officer is generally based upon the special branch of Ordnance Engineering which he desires to follow, such as Chemistry of Powders and Explosives, Gas Engines, Metallurgy, Physical Research, Electrical Engineering and Mechanical Engineering, including an advanced study of the Theory of Elasticity. When practicable, the course for each student at an educational institution is laid out to enable the individual to obtain a Master's Degree.

Courses in Research at the Watertown Arsenal and in commercial plants are available for officers specializing in a particular line of work, such as metallurgy, steel making, manufacture of chemicals and methods of production.

It is the policy that, prior to an officer of the Ordnance Department being assigned in charge of an important division in the Office of the Chief of Ordnance or to the command of an arsenal, the Course in Administration and System of Management should be taken. This course includes a study both in private commercial plants and at the Watertown Arsenal of the methods of determining the kind and quantity of materials required in the execution of an order, the various processes and operations by which the raw material can be fabricated in the shortest time and at the least cost into completed components and assembled into finished articles; the types of machines, equipment, fixtures, tools and gauges required in the performance of work; the assigning of operations and processes and the routing of materials and component parts through the various operations and processes; a study of the number of employees that can be efficiently managed by one supervisor and of the duties, responsibilities and authority of supervisors; the working out of organizations for manufacturing plants and a study of the relations between employers and employees, including working conditions and wages. The material changes that have occurred in the past few years in industrial relations make necessary a knowledge of the various lines along which this relationship has been improved before an officer can satisfactorily direct a manufacturing plant. The basic principles of cost keeping and their practical application are given special attention.

The courses for officers of the National Guard and Organized Reserve consist of a basic course which includes Testing Materials, Specifications, Pyrometry, Administration and Inspection, and has for its object the covering as well as can be done in one month the general duties of an Inspector of Ordnance. The Second Course includes Metallurgy and Metallography and one of each of the following three electives, namely:

1st Elective—Metallurgical Chemistry;
2nd Elective—Heat Treatment;
3rd Elective—Pattern Making, Molding, Melting, Annealing and Chipping.

The Third Course includes tolerances in dimensions and their effect on the production of ordnance, effect of maximum and minimum limits of dimensions on production, the use of jigs, templates and guages, the preparation of inspection reports and the inspection of the product of the arsenal.

One month is allowed for each of the above enumerated three courses and they are arranged so the courses can be taken in successive years, as few officers of the Reserve Corps and the National Guard can spare more than one month per year on active service.

Special courses are prepared to meet the needs of individual officers in any branch of science or engineering, including research work, when an officer of the Ordnance Department is designated by the Chief of Ordnance to take a special course. Special courses are generally given at the Watertown Arsenal although they may be taken at a

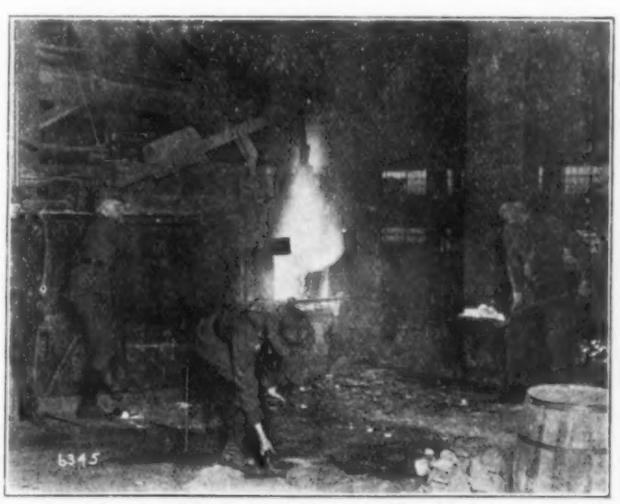


Fig. 3. Making Electric Steel.

private educational institution or in a private manufacturing plant.

All of the Courses enumerated above form part of the Ordnance School, which is governed by a Faculty Board, the membership of which consists of the Commandant, who

is the Commanding Officer of the Watertown Arsenal, an Assistant Commandant who handles executively all matters connected with the School, of the Director of Laboratories and of the Superintendents of the Machine Shop and Foundry Departments.

Almost all work done by student officers in Course II is

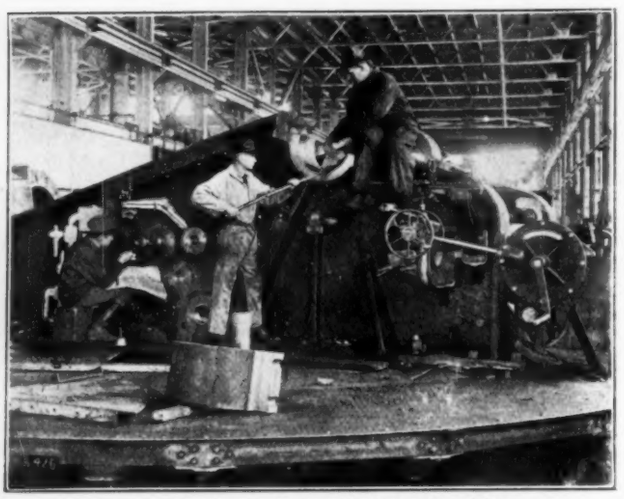


Fig. 4. Erecting the 16-inch Howitzer, Model 1920.

performed on productive work, that is in the making of components for issue to the service. This not only decreases the cost of instruction but enhances the interest of students in their work.

While the Ordnance School is primarily operated for officers of the Ordnance Department, it is the policy of the Chief of Ordnance to encourage officers of other branches of the service to take to the extent permitted by appropriations Courses I and II, as the knowledge gained has proved highly beneficial to the Line of the Army and helpful to the Ordnance Department in the discharge of its duties. Since the World War, an appreciable percentage of the officers taking Courses I and II have been officers from the Line branches.

As the object of the Ordnance School is to assist student officers to assimilate basic principles so they can be used rapidly and correctly in their practical application, the Faculty Board manages the School to insure the attainment of this primary object. No attempt is made to grade graduates and work is marked only to the extent necessary to insure that certificates and diplomas will be awarded only to those who satisfactorily complete each study. The Massachusetts Institute of Technology assigns Professors and Associate Professors who have established enviable reputations in their respective lines to the instruction of student officers. The instruction at Watertown Arsenal is principally given by supervisors in the laboratories and manufacturing plants who retain their positions through their technical and practical knowledge in their respective trades, and who make their living by their efficient production. There are several other important advantages connected with the Ordnance School that will not be found in any similar institution.

Diplomas are awarded for the satisfactory completion of Courses I and II. Master's Degrees are awarded to those student officers by private educational institutions who satisfactorily complete a Post-Graduate Course. Certificates of Proficiency are issued to student officers who satisfactorily complete either Course I or Course II, and the Special Courses and Research Work.

Tolerances on Projectile Dimensions

The Ordnance Department has, for some time past, been conducting experiments as to the effect of tolerances on projectile dimensions, with a view to securing increased accuracy while at the same time keeping the dimensions within those which can reasonably be prescribed in manufacturing operations.

It is evident that the larger the tolerances are the cheaper it will be to manufacture the shell, while on the other hand one would expect that the smaller they are the more accurate would be the ranging of the projectiles.

The problem of deciding exactly what these tolerances should be is one of the most important and difficult of the problems of the projectile designer. Until recently there have been almost no data available on which to base such a decision. At present, however, as a result of a 1500-round rangefiring program for the 155 mm. G. P. F. gun which has just been completed, the Ordnance Department is in possession of information concerning the effect of changes in these various dimensions on range, and can base its decisions in this regard on rational grounds.

It was found in these firings that a change in almost any of the dimensions exerts a noticeable influence on the range, and that the range is very sensitive indeed to changes in certain dimensions. This general result is apparently contrary to what had been obtained in certain firings before the war.

On the whole the results justify the Ordnance Department in regard to the general magnitude of the tolerances which were imposed during the war. In the case of certain dimensions they might well have been larger, in other cases they should have been smaller.

The program mentioned above should, however, be regarded as only a beginning, for the results obtained from it are only applicable to a projectile of a given size and shape when fired with a given muzzle velocity at a given elevation. To extend this program by range firings so as to cover the various combinations of shapes, sizes and muzzle velocities, would involve an enormous expenditure of ammunition. As a result of the extensive program of air resistance firings now commencing, it is believed useful data on this subject will accumulate at much less expense.

There are undoubtedly some projectile shapes which are

Breaking down an Ingot at the 800-Ton Forging Press.

much more sensitive to slight changes in dimensions than others. In its future design work the Ordnance Department proposes to make a study of the problem from this point of view, with the object of selecting those shapes which will permit the greatest tolerances on dimensions for a given effect on range.

Aircraft Guns

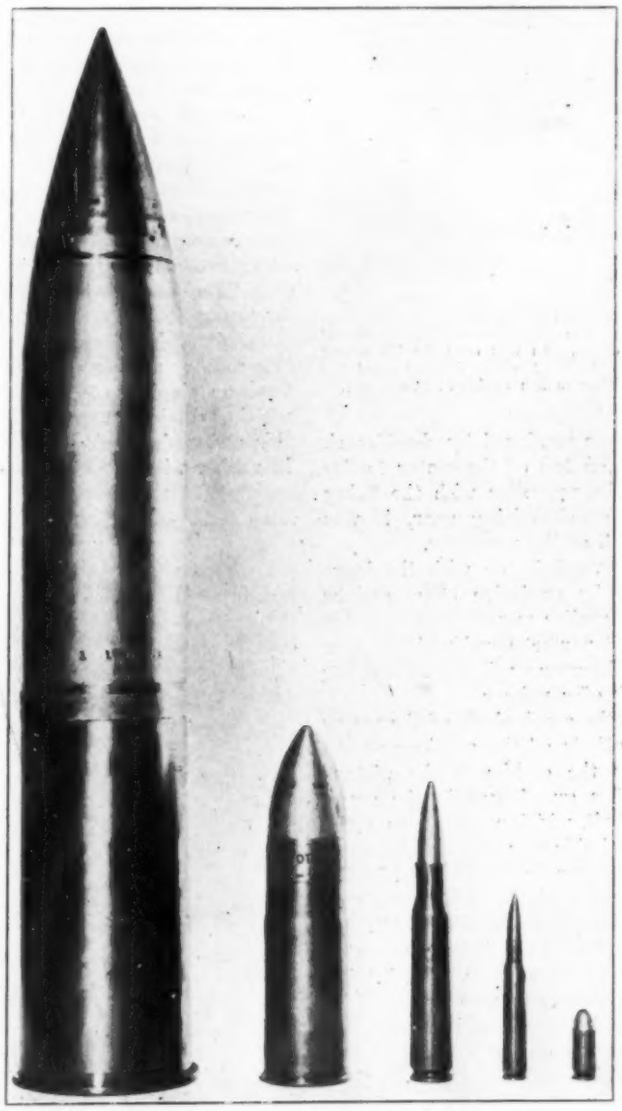
PART II

By

WM. A. BORDEN
Member A. O. A.

COMBATS between aircraft were still infrequent occurrences when it became apparent that very few hits made with machine guns were effective. On the return of an airplane to the field after an encounter, numerous holes would be found where ineffective bullets had passed through the fabric and structure. The vulnerable target for machine gun bullet hits included the pilot, the engine and the gasoline tank and was comparatively limited in size. The only means of increasing this target was to make all hits effective wherever they might occur on the airplane structure. This could only be accomplished by firing explosive projectiles, which bursting on impact would cause damage not only at the point struck but at all points hit by its fragments.

Airplanes fly for protection in formation and it is difficult for attacking airplanes to come in close and inflict damage, as the formation is such that in the attack the hostile airplanes will be subjected to the combined fire from all or several airplanes in the formation. However, if one of the airplanes becomes separated from the formation, the task of shooting it down is not particularly difficult. In combat it soon developed that, to be successful against airplanes in formation, the formation must be broken up and the airplanes so scattered as to become the prey of waiting hostile aircraft. This could only be accomplished by employing gun fire superior in range and destroying effect to that of the enemy. To produce a weapon which would meet this requirement and also fire explosive ammunition necessitated the development of larger caliber aircraft guns.



Aircraft Gun Ammunition.

The trend in development of aircraft guns as indicated by the ammunition fired. First the pistol was fired in combat as represented by the .45 caliber round on the right. Then the .30 caliber rifle and machine gun were used. The addition of armor required the development of the .50 caliber gun and the need for explosive projectiles brought out the 37 mm. The 75 mm. gun was developed for use in the attack of submarines and for bombardment and there is every indication that a gun of this caliber will be needed for aerial combat by certain types of aircraft.

Having nothing better to use as a guide, the natural tendency was to again turn to the ground weapon and select one which could be adapted for aircraft use. The Italians had brought out a 25.4 mm. gun for aircraft use but tests of it had not been very promising, as the explosive shells were not large enough to be effective and with this small caliber a satisfactory senstive fuse required for aircraft attack had not been developed. There were no large ground type machine guns which could be utilized as none larger than the one already used in the air had been produced. In fact, no mechanism was at hand which would fire automatically a projectile large enough to give a proper explosive effect.

The minimum caliber for such a weapon was indicated by ground experience to be about 37 mm. The question was studied and it was determined that a gun of this size could be mounted in aircraft and fired at high enough velocities to be effective without overstraining the structure of the airplane. The British and French therefore immediately undertook the development of a 37 mm. aircraft gun.

The lessons learned with machine guns had indicated that aircraft guns of larger caliber should be of the fixed and flexible type. They should also be full automatic in action; that is, they should be operated simply by pulling the trigger, the firing and loading operations continuing without further effort on the part of the gunner. The French had solved all the essential problems involved in a gun of this caliber, but it was semi-automatic in action—requiring that the gunner

re-load the gun after each round fired. It was realized that this feature would prevent the gun from being as effective as a full automatic weapon, but since the development of a full automatic gun would be difficult and require considerable time to accomplish, the use of the semi-automatic principle was decided upon.

Effect of One 37 mm. High Explosive Shell on Fuselage of An Airplane.
A machine gun bullet hitting in the same place would probably not have done any damage. The explosive projectile makes almost all hits effective wherever they may occur. In this case the hit would have brought down the airplane. Such an effect demonstrated the need for guns large enough in caliber to fire explosive projectiles.

The first gun of this type was produced by the French and instead of being mounted on top of the motor to fire through the space swept by the propeller with the firing of the gun controlled by a synchronizing gear, it was mounted to fire through the hub of the propeller.

Synchronization was not attempted, for with the large caliber of the projectile and its explosive effect serious damage would result if the propeller were struck and this might occur even with the most perfect synchronizing gear through some error in timing the gear or through the firing being delayed by a "hang fire" of a primer.

The propeller is attached to the crank shaft of the motor in the usual design, but the offsets of the cranks and the connecting rods leading from the cranks to the pistons would prevent a mounting of a gun barrel in the crank shaft. A hollow propeller shaft which would encase the barrel of the gun was used and this was offset and geared to the crank shaft to allow the gun to be mounted in the "V" of the motor above the crank shaft. The muzzle of the gun protruded through the hollow propeller shaft.

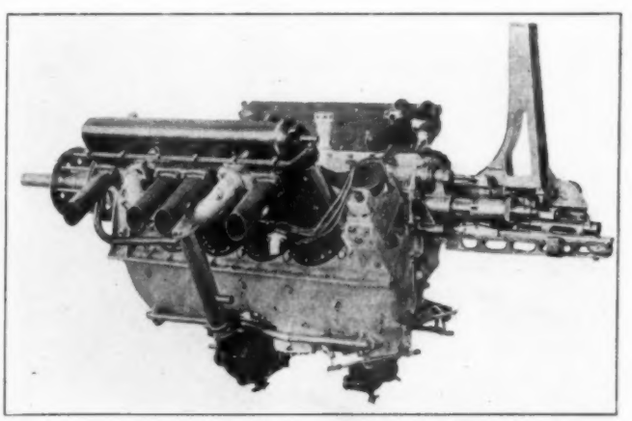
One of these guns was built into a specially constructed airplane and given to Captain Gynnemer, the leading French ace at that time. A similar gun was also used by the noted French ace Fonck and it is reported, though not officially verified, that with such a gun this intrepid flier shot down six airplanes in one day with the expenditure of only eleven shots. These guns were, however, reported upon unfavorably as they required a special airplane and a special motor and were of the semi-automatic type. The semi-automatic feature as stated necessitated the reloading of the cannon between rounds, which was accomplished with difficulty as it required the complete attention of the pilot even to the exclusion of watching his opponent during combat.

The British developed a full automatic 37 mm. gun but it is believed that none of these was used, for when active operations ceased the full automatic feature had not been perfected to the point where reliable functioning was obtained.

The limited use by the French of the 37 mm. cannon completely demonstrated the actual need for a weapon of that caliber. It could fire explosive projectiles with supersensitive fuses which would function on impact even with the lightest fabric used to cover the wings or fuselage of an airplane, and armor piercing projectiles which could penetrate the heaviest armor capable of being carried on aircraft. Projectiles carrying relatively large amounts of incendiary and tracer material could be used and during combat at close range canister could be fired which would project numbers of lead balls from the muzzle of the gun, giving a shot-gun effect and thus increasing at these ranges the effective field of fire.

An air force equipped with these weapons could lurk beyond the range of the aircraft machine gun fire of an opposing force, outrange its opponents, stand them off during combat and destroy them without entering the danger zone of hostile aircraft fire. Although in the past war the use of these weapons was limited, the next war will see them used in increasing numbers and it is natural therefore that the energies of the various countries of the world should now be centered on the development of full automatic guns of approximately 37 mm. in caliber for use on aircraft.

Guns of even larger caliber than the 37 mm. were under development for use in aerial combat when the war was terminated. A 75 mm. aircraft gun had been produced in this country and tested on the ground but it was never fired from an airplane. Only further development will indicate whether combat weapons of the air will be extended beyond this caliber but it is believed that guns of at least 75 mm. in caliber will be mounted on dirigibles if not on airplanes



A 37-mm. Gun Mounted in the "V" of a Motor.
The propeller shaft is geared to the crank shaft and is hollow. It carries the barrel of the gun which allows the gun to fire through the propeller. The gun is not mounted over the motor and controlled by a synchronizing gear to fire through the space swept by the propeller as is done with machine guns because a primer in a cartridge might hang fire delaying the actual firing of the gun so that the propeller might be struck by the projectile. With explosive ammunition this would be disastrous and even one hit with a non-explosive projectile of this size would shatter the propeller. The effect of blast from the muzzle of the gun on the propeller when firing is uncertain and probably would give trouble.

and be a deciding factor in future struggles for supremacy of the air.

Although the primary function of aircraft guns was the destruction of hostile aircraft, the increasing activity of the airplane during the war opened up a new use for these

weapons in the attack of targets on ground and sea. This method of attack was initiated by venturesome aviators who would fly low over exposed hostile troops, convoys, wagon trains, cantonments and other targets vulnerable to machine gun fire, and directing their guns downward would discharge them with effective results. There were numerous instances of attacks of this kind, quite a famous one being that of a French squadron which flew low beside a moving railroad train carrying hostile troops and fired into the windows of the train, killing and wounding many and producing untold confusion.

As the war progressed, special airplanes were equipped with numbers of machine guns trained downward for the particular purpose of trench "strafing." This mode of fighting developed the attack airplane and during the last period of the war, the use of attack aviation for combating vulnerable targets on the ground became a recognized addition to the tactical employment of aircraft. With the development of armored airplanes equipped with many machine guns and large caliber full automatic cannon a real tank of the air is in sight which in the future may prove the greatest foe of the ground tank.

The submarine offered a very tempting target to gunfire from the air for if its hull could be punctured it could not submerge but would be forced to remain above the surface where it would meet certain destruction from the gunfire of such naval vessels as were in the vicinity or were called there by wireless from the attacking aircraft. To effect a puncture a gun of considerable size and power would have to be employed not only to penetrate the steel plating of the hull but to produce a hole which would be difficult or impossible to plug. Guns of 47 mm., 65 mm. and even 75 mm. in caliber were mounted on airplanes, seaplanes and dirigibles for this purpose.

Our Navy mounted the 6 and 9-pounder Davis non-recoil gun (approximately 2.25" in caliber) in the nose of seaplanes for use against submarines. These Davis guns are designed so that a dummy slug is fired out of the rear end of the gun at the same time that the projectile is fired from the forward end. This slug is so adjusted that the recoiling forces are balanced and there is no strain on the mount. The guns developed abroad did not employ this principle and had therefore to be mounted on very large

A 37-mm. Gun Mounted as a Free Gun.
Such a weapon is capable of firing an effective explosive projectile and when developed to fire automatically will probably be used as an offensive weapon on all aircraft on which it can be carried.

and sturdily built aircraft in order that the forces of recoil might be taken up without danger of overstraining the structure.

During the war aircraft relied mainly upon bombs for the attack upon such targets as buildings, lines of communication, ammunition dumps, storage depots and manufacturing plants. In bombing there is only one point in the sky from which a bomb can be released under a given set of conditions and hit the target. If the bomb is not

The Davis Non-Recoil Gun
This gun was mounted by our Navy on hydroplanes for use in the attack of submarines. When fired, a slug or charge is fired from the rear barrel at the same time that the projectile is fired from the front barrel and thus the recoil forces are balanced and there is relatively little reaction on the mounting. The guns were about 2.25-inch in caliber and fired 6 and 9 pound projectiles. The Lewis Gun mounted above the Davis Gun is used for the purpose of directing the fire of the larger gun. When the impacts of the bullets from the machine gun are seen to bear the proper relation to the position of the target the larger gun is fired.

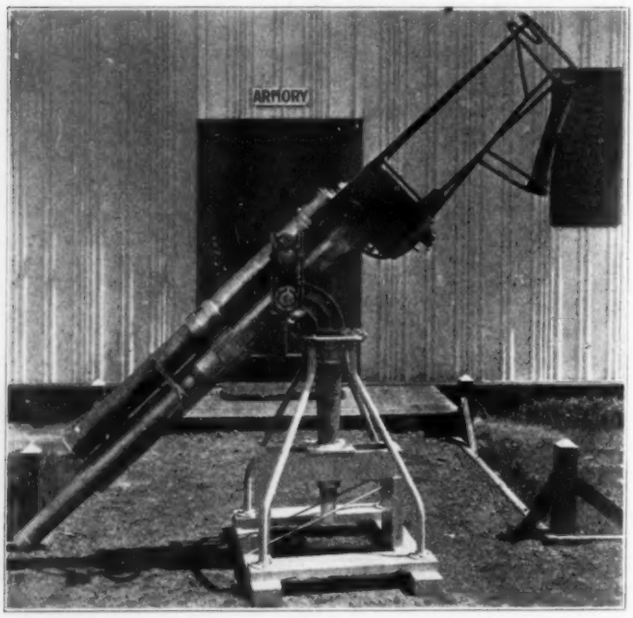
released at the instant the airplane passes over this spot or if the airplane is not directed over the particular point the bomb will not hit the target. In this event either the bomb will be wasted or the airplane must turn about and attack the target again. This is a difficult practice with airplanes flying in formation in the presence of hostile aircraft and anti-aircraft fire. If a bomb could be given an initial velocity and an initial direction which could be adjusted in accordance with the position of the airplane with respect to the target, it would not be necessary to fly in any definite direction or release the bomb at any definite instant in order to hit the target.

Since this could not be done in any practical manner, consideration was given to the firing of guns from the air in bombardment operations. A gun would give initial velocity to the projectile, could be directed at the target permitting the airplane to fly in any direction within its range and if properly pointed would fire the projectile so that the target would be hit.

In developing a weapon for this purpose a 75 mm. bombardment cannon was produced and mounted to fire through the floor of an airplane. The actual test of this cannon was not completed by the end of the war and therefore no conclusion in regard to its possibilities can be drawn.

It remains to be proven that the accuracy obtained with a bombardment cannon will be equal to or greater than that obtained with bombs. The cannon represents a dead load which must be carried both to and from the objective

and which, for a given carrying capacity of an airplane, limits the number of projectiles that can be taken. When bombs are used there is practically no dead load carried



The French 75-mm. Semi-automatic Gun for Mounting on Aircraft for Attack of Submarines.

and therefore a greater amount of high explosive can be dropped against an objective than could be fired by a bombardment cannon from the same aircraft. In addition, all the load is released when the bombs are dropped, allowing the aircraft to return to the home field unburdened. These considerations are responsible for doubts which exist as to the value of bombardment cannon and therefore such a weapon must be carefully tested before it can be definitely known that it can supplement or partly replace bombs in bombardment operations from the air.

Though great progress has already been made in the development of aircraft guns there is still a large field to cover in the investigation of these new weapons of warfare and the extensive uses to which they may be applied. Already we have progressed from firing a pistol in aerial combat to the use of the .30 caliber, the .50 caliber, the 37 mm. and the 75 mm. gun, but we have no definite reasons for believing that the maximum size of caliber for use in the air has been reached. We have seen ground guns converted to aircraft use, then refined and developed into strictly aircraft guns. We have found that aircraft guns must of necessity be lighter than ground guns, that because of the fleeting nature of the target they must fire at a higher rate of speed and that they must function under more extreme variations of temperature, even under the very low temperatures encountered in high altitude combat. They must be capable of firing in almost every position, sometimes almost upside down, and they must be compactly designed so that they can be satisfactorily mounted in aircraft. They must be able to fire at high velocities without subjecting the structure of the airplane to excessive strain and, above all, in their functioning, they must be entirely reliable.

In the race of guns versus armor for aircraft the guns are now far ahead. Although aircraft depends to some extent on armor for protection, its main reliance is in speed, maneuverability and superior gunfire. Speed and maneuverability are factors with which guns must compete and for this high rates of fire and high velocities are necessary. For superiority in gunfire, guns must compete with similar weapons which an enemy may bring out and here the trend is toward larger calibers.

It is vital that development work on aircraft guns go on without interruption and be favored above other munitions, as the part to be played by artillery of the air will be so important that even as a preponderance of sea-power has been a deciding factor in conflicts of the past, the future will see victory dependent upon air supremacy obtained by a superior air force equipped with efficient aircraft guns.

A Bombardment Cannon.
The muzzle of the gun is seen projecting through an opening in the bottom of the fuselage of the airplane. The mechanism of the mount allows the gun to be directed forward and back and to the right and left of the vertical thus permitting the gun to be trained through a limited field of fire.

Aircraft Automatic Cannon

The effect of the World War on armaments has resulted in attempts by England, France, Italy, the United States and Germany to develop automatic cannon of small caliber, primarily intended to be mounted on airplanes. Until the present time the results have not yet pointed a way to the completion of a successful model. Usually the design of experimental models has been based on principles commonly incorporated in machine guns of the most successful types, in which the bolt retracts from the breech at least a distance as great as the length of the cartridge, which is fed into the chamber while the bolt is in the retracted position. Some types are designed to cause the bolt itself to feed the ammunition into the gun. Such a method of operation is very successful for small caliber machine guns, and in the opinion of some designers, it is thought to be the best principle for operating the cannon of small calbers. Some authorities believe that it is a method which can never be used, and give the following reasons. Medium caliber cartridges cannot be moved with as much violence as the small caliber ammunition which is used in machine guns because of the greater weight involved. The instruction necessary to produce a gun of sufficient strength causes the weight of the gun to be a prohibitive factor, since it is estimated that the weight of such a type of weapon is increased as the square of the diameter of the bore, which amounts to a weight of 1200 pounds for a gun using ammunition loaded with a projectile 1½ inches in diameter.

The United States Army Ordnance Department has only recently entered a comparatively new field of automatic cannon development, which mainly comprises the construction of a full automatic cannon of 37 mm. or 1½ inches in caliber by converting a standard cannon, made to meet the requirements by the addition of an automatic feed. The first gun of this type is now being constructed at one of the Arsenals and should be ready for test in six months. Still another design is under preparation, the first model of which should be completed about the same time.

The Infantry Tank School

Its Relation to the Ordnance Department

By

S. D. ROCKENBACH

[General Rockenbach served as Observer with the German Armies in the field in 1914-15. He went to France on General Pershing's staff in May, 1917, and became Chief of the Tank Corps, A. E. F., in December of that year. He directed the organization and training of this Corps from its inception and directed the operations of the Tanks in the St. Mihiel and Argonne-Meuse offensives. At the present time he is Commandant of the Infantry Tank School located at Camp Meade, Md.—*Ed.*]

THE tank is the pioneer in mechanical warfare on the battlefield and a clear understanding of it requires a consideration of general principles. The principles of mechanical warfare, the employment of machines in war, are the same as are those for the employment of machines in industrial life. A machine increases the productivity of manual labor, but it does not replace it. A machine with a few men does the work of many men, but it must have the men necessary to operate it and the necessary number to take its products and usefully dispose of them. So with the one machine of the war produced entirely by the Allies, the tank, it does not replace infantry, cavalry, or artillery; it mechanizes them and aids them to conserve their energy and apply it where most needed. The machines of war differ from those of peace, in that they must have the mobility of the troops that employ them.

General Rockenbach.

It must be kept in mind that the tank is a machine weapon; it is a land cruiser capable of crossing country with greater speed than a rifleman, it gives protection for its crew, and enables them to reach and concentrate great gun power on strong points; and it is capable of great shock action. It is a conserver of time, men and supplies.

The light tank company, operated by 145 men, has a gun power equal to three machine gun companies (war strength) which require 420 men.

The medium tank company, operated by 145 men, has a gun power of four batteries of six-pounder guns and four machine gun companies, which require 1,360 men.

A heavy tank company, operated by 320 men, has a gun power of eight batteries of six-pounder guns and ten machine gun companies, which require 3,000 men.

This comparison does not consider the great value of the tank as an obstacle crusher, as a demoralizer, as a self-contained transportation unit, as cover for its crew, or that each company has an armored mobile radio station.

Neither is it overlooked in this comparison that back of the fighting companies are the Tank Maintenance Companies; back of them, the Ordnance Maintenance Companies; back of them, the Ordnance shops; back of them, the Ordnance manufactories; and back of them, the manufactories producing the raw materials; so that to fight one man at the front in a tank, in a ship, or with the modern cannon, we must employ many men. Modern war does not require the nation in arms but it demands the employment of the nation in the business of war. The gain by mechanical war is that in addition to the economy in lives, *that nation suffers least which goes from peace to war with the least change and disturbance of its industrial life.* To convert our peace industries into war industries and then, when war is over, have them resume their peace work is much less disturbing and less costly than to close them and put their trained employees into the line of an army where they know nothing and suffer great losses due to lack of training.

The principles of war are immutable. War is movement. Successful war requires the proper balance between mobility and power and the correct employment of the combination. A battle may be won by a superior force, but there is no victory unless the superior force has the remaining energy and the mobility to follow and destroy the enemy and the enemy's country until he is ready to sue for peace and serve the sentence the victor imposes.

In the World War, destructive power had increased a thousand fold over that of the time of Napoleon and of our Civil War, due to the concentration of energy by railways and highways; but mobility on the battlefield had decreased to such an extent that while either side could shoot the other off the earth for a space of ten to tweny-five by eight miles, neither had the energy and the mobility left to follow and hold (roads having been destroyed). On the first of April, 1918, the obstacle between the Germans and the English Channel was exhaustion and the lack of cross-country transportation. The blows given and received were so paralyzing that recuperation for another effort required months.

Means to overcome machine guns, wire entanglements and trenches without exhaustion had to be devised. Hence, the tank was devised to move independent of roads, to crush

obstacles and carry protected gun power into and beyond the enemy's lines so that a superior force can reach him. It augments the fire power of the rifleman at critical points and enables him to make use of its destructive work. The tank, the land cruiser, must have great speed and durability in order to concentrate gun power at the different critical times and points and in order to escape destruction by artillery. It will more than replace the horse artillery of the Napoleonic wars and of our Civil War.

The first essential of the tank is ability to cross country. General Swinton of the British Army, on seeing a caterpillar tractor, conceived the tank. A naval constructor, a banker and a cabinet minister planned, promoted and made possible its construction.

The British studied and designed "machine gun destroyers" from October 1914 till June 1915, but made little advance, due to lack of coordination. Then the landship committee was constituted. It promptly rejected the Juggernaut of 1000 tons and the 15-ft. wheel tractor type and concentrated on the caterpillar tractor type. The first of these, the Mark I, was produced early in 1916 and fifty were turned out and used in the Battle of the Somme, Sept. 15, 1916. The mechanical defects learned in this and subsequent battles led to the design and construction of the Mark II, the Mark III, and finally the Mark IV, of which, by November 1917, 500 were ready. The mechanical struggle to improve the machines was easy compared to that of overcoming the prejudice of the old army and getting a fair try-out. This first came at the Battle of Cambrai, Nov. 20 to Dec. 3, 1917. The success gained by tanks on the first day was so stupendous that it not only caused rush orders to be given by the British Army for improved tanks in large numbers, but also by the French and American. The British had already started to improve the Mark IV and the lessons of Cambrai called for a medium fast tank; hence, the Whippet.

The battle of Cambrai demonstrated the necessity for a land fleet composed of heavy tanks for penetrating the enemy's fortified lines, light fast tanks for exploiting the break through, cross-country gun carriers, infantry carriers and supply carriers. No type of heavy tank in production was satisfactory, so we went in with the British for the production of our present Mark VIII. There was no suitable medium fast tank in production, so we took the French light Renault, improved it, and produced it in large numbers—our present 6½-ton tank. For carriers, we proposed to use Holt Caterpillar tractors with suitable bodies.

Eight months after the Battle of Cambrai, the British fought the great tank battle of Amiens. In this battle, the type of tanks used at Cambrai had been discarded for fighting and, after having been modified, used for carriers, while the new Mark V and Whippets did the fighting. The war ended before a new type of tank free from the defects and weakness of the types used at Amiens could be produced. We have not yet produced the tank with the mobility we learned at Amiens a tank must have.

The Tank School is but a combination and development of the heavy tank school that we maintained in England with the Britsh during the last eight months of the World War and of the light tank school that we established and operated in France with American officers trained in the French schools.

The war methods have been kept up and until the individual is trained to operate the tank, its guns, and the motor equipment, few books and little theory are used. Officers enter the school with beliefs based on the valor of ignorance and it is not until they are shown what Tanks can do and especially until they are taught to operate Tanks over difficult terrain that they see their value and can direct them with economy and efficiency. It is thought that this method alone will keep our army from becoming antiquated.

The efforts of the Ordnance Department and the Quartermaster Corps to equip the Army with the necessary machines for modern war will be futile unless the officers of the line can be made to acquire the habit of economically and efficiently operating and directing them. This ability requires no great amount of intelligence or technical knowledge. Aberdeen unquestionably possesses men of higher technical skill and training than the 30th Ordnance Maintenance Company, yet to operate a Mark VIII Tank continuously and efficiently, it is necessary to get a man from the 30th Company who has acquired the habit of operating the machine and the belief that it is durable.

The object of the Tank School is two-fold: the training of personnel and the study for the development of improved tanks and equipment.

The individual officer and soldier is trained in the operation, maintenance, control and employment of tanks, and then goes into an organization where the habit of operating the machines is acquired. The general influence of the school is to hasten the comprehension that modern war is a war of machines and that the soldier must learn to operate them; that modern Infantry is technical Infantry, and that its personnel must know the automatic rifle, the machine gun, the accompanying cannon and the tank as thoroughly as the rifle was known.

In the next war, machines are going to supplement the efforts of flesh and muscle to a larger extent than ever before, and success will require the personnel to be trained in the habit of operating machines, and to appreciate that the advent of improved machine weapons on the battlefield requires modifications in tactics to make the best of them. The situation is similar to that of the automobile thirty years ago. The conception and idea in the minds of a few were as clear as they are today as to the usefulness and value of motor vehicles, but a doubting public would have nothing to do with them. It cost millions of dollars and years of designing and redesigning to produce reliable machines, and then years of demonstration to convince the world that a technical education resulting in the acquiring of much mechanical knowledge was not necessary to the safe and useul operation of a motor vehicle. They are best operated by painstaking persons who acquire the habit. Dreams are dreamed in an instant, and machines embodying them are quickly built; but mass education requiring the departure from old habits and ideas, which is necessary to make the dreams come true, is slow and requires much time.

The study for the improvement of the type of tank in use is continuous. It is recognized that the tank of the World War is but the first and a poor type of a machine which was built to embody mobile, cross-country, protected gun power with shock action. The types of tanks in use are improvements on any produced during the World War and the type being built is a great advance on its predecessors but it is recognized that the last word in tanks has not been said. The conception of the tank is correct; the best type so far produced is in its infancy and suffering from infant troubles. It is necessary to keep in mind that the tanks are land cruisers and their successful operation requires a well-balanced fleet composed of gun carriers, cargo carriers, repair-shop carriers and troop carriers. The influence of the British navy in the production and employment of the tank was large and directed along correct lines.

Method of Training

The training is practical and efficiency is determined by performance. The following routine is followed:

The recruit, the first month, is given an intensive course in the training and duties of the soldier, to include the school of the company. He is then started in one mechanical school and one gunnery school. On satisfactory completion and display of sufficient intelligence, he may start on reconnaissance or signaling. On completion, he is assigned to a tank company for platoon and company work. Tank drivers from the companies are sent to the motor vehicle school, where they quickly acquire the ability to drive a truck. Thus, all the personnel in the center is used for training. It is in the company that the practice is given and the habit acquired that makes the skilled tank operators.

A Divisional Tank Company (Light)
(Peace Strength)

Five officers and 105 soldiers, 24 fighting tanks, 1 radio tank, 25 Mack trucks for tanks, 1 Artillery repair truck, 1 Artillery supply truck, 6 cargo trucks, 1 light supply truck, 1 gas truck, 1 automobile, 2 motorcycles. Total 63 motor vehicles.

One kitchen trailer, 1 water trailer, 10 37-mm. guns, 14 machine guns.

The Tank Group

The object of the group is to furnish in time of war the nucleus of the tank force for the first army; and in time of peace, an operating organization in which the trained individual gets the habit of operating tanks and combined training in the platoon, company and battalion. The officer gets practice in operating tanks with the Infantry. It would be ruinous to let any untrained individual into the group, hence all officers and non-commissioned officers must be able to drive tanks.

Relations to the Ordnance Department

The relations established by the Chief of Ordnance and the Chief of the Tank Corps in December, 1917, at the Headquarters of the A. E. F. have not been interrupted. Briefly, they were that the Tank Corps was to state its requirements and the Ordnance Department would make every effort to meet them. Fortunately, the first Ordnance representatives for tanks consisted of a combination which, for a broad knowledge of tanks and their employment and technical skill could not be excelled. When we learned from the "Tommy" that the best British tank used at Cambrai was a "deaf, dumb and blind beast," no argument was necessary with Col. Drain and Col. Alden to convince them of the fact. The Ordnance officers then kept up with the Tank needs by personal touch, and so it is with the Ordnance organization at the Tank School now. It is believed that more work is done here with less correspondence than anywhere else in the Army.

The war demonstrated that the successful operation of Tanks required a clear understanding and separation of the functions of technical and tactical maintenance. The first pertains to the Ordnance Department, which has all the classified mechanics; and the second, to the Tanks, whose personnel is made up of operators.

(a) Technical Maintenance.—The Ordnance Department secures by manufacture or purchase all tank equipment required by the Tanks.

The Tanks give general specifications for what they want; the Ordnance Department designs, produces, and delivers at the rail head, where they maintain a depot and a Heavy Mobile Ordnance Repair Shop for tuning up and repairing breaks, replacing tanks, and furnishing spares.

(b) Tactical Maintenance.—In the zone of advance and in training centers, maintenance is performed by tank personnel; that is, replacing broken or damaged parts and making such minor repairs as can be done with the tools allowed in the organization equipment.

Divisional companies, battalions, and groups have mobile repair shops and maintenance units.

The practical operation of this is as follows:

The Ordnance Depot and Maintenance Company are assumed to be at the railhead; in advance of this, the Tank Maintenance Company; and in advance of this, the operating organizations. A tank becomes disabled; if within the ability of the platoon, company, or battalion, broken parts are replaced by spares and the tank is repaired with the hand tools furnished. If beyond their ability, it is turned over to the Tank Maintenance Company, which replaces broken parts with spares or makes such repairs as can be made with their tools. It also furnishes the Commanding Officer with a report of *the cause of damage.* Whenever damage is due to neglect or carelessness, the organization commander is called to account.

Broken parts and major repairs are turned over to the Ordnance Maintenance Company. The important thing is that when the Ordnance returns a tank to an organization, it is demonstrated to be serviceable to a tank squad. All controversies disappear when referred to the first agreement. Tanks state their requirements the Ordnance atment. Tanks state their requirements; the Ordnance at-

The Tank Board.—Since the merging of the Tank Corps into the Infantry, the Tank School maintains a Tank Board for keeping abreast of Tank improvements and developments and for advising the Chief of Infantry on matters of organization, production, and training. Touch is maintained by a liaison officer, who also sits with the Ordnance Tank, Tractor, and Trailer Division.

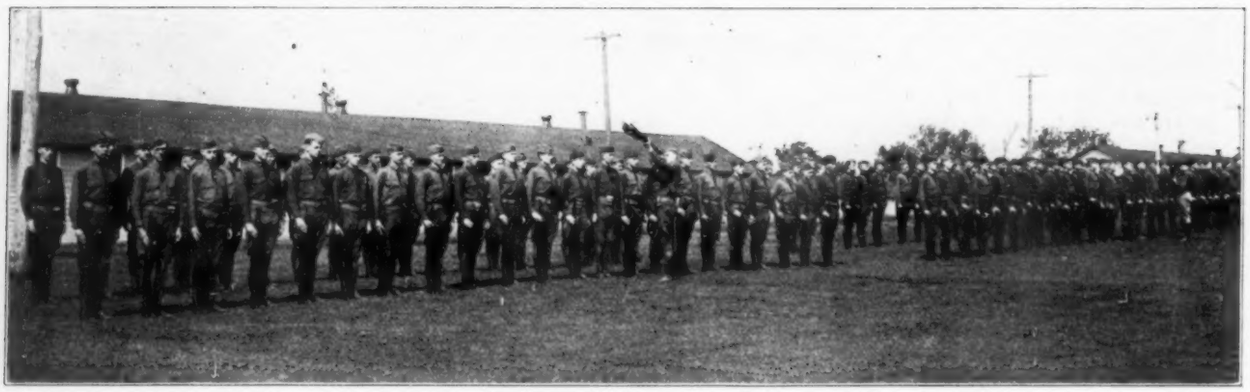
The cost of producing and maintaining sufficient tank equipment for an Army of the probable size we will require in an emergency is prohibitive and by the time it might be produced, it would likely be obsolete. The policy that has been approved by the War Department for tanks is to maintain what we have in readiness for battle and training, plan and produce a pilot embodying all the approved ideas, try it out, perfect it, then build enough of the approved type to equip a company for tactical study, and with them secure the jigs and tools necessary to put the type into quantity production.

As it takes eighteen months to produce a tank, starting with the design, this policy saves us eighteen months in an emergency. In six months more, or as quickly as we could get the personnel, we would have tank equipment. In addition, if we can standardize the chassis of the tank for general Army use and demonstrate to the public that it is of great commercial value, the essential part and the big part will be in quantities when needed for war, just as the automobile and truck are.

The matter of putting on the chassis a body suitable for tank, suitable for truck, suitable for a gun or omnibus is simple. This last the French have done recently in North Africa with considerable success. On land, man is restricted to his expensive and laborously built roads; cross-country transportation is necessary for his progress and full utilization of the earth.

To the Ordnance Department the Tanks say: "We want a machine with a real caterpillar tread, capable of conforming to inequalities of the ground, elastic suspension for speed and durability, a speed off roads of 12 m. p. h., the speed of army trucks on roads, weight and dimensions to be such as to enable them to use highways and highway bridges, armor protection against machine gun and rifle bullets, a cruising radius on one fill of gasoline of 100 miles, and an armament of one 6-pounder and two machine guns."

In the victory that will follow the employment of such a machine, the men who make it will share equally with those who wield it.



Future Ordnance Officers

By

A. W. MAISH
Member A. O. A.

FOR the first time in the history of our country we have a military policy. The National Defense Act of 1916, born in the stress of imminent war, modified in 1920, as a result of our experience in France, gives us a definite plan for utilizing effectively our enormous manpower in case of a major emergency in a manner in keeping with our national traditions.

It provides for a small Regular Army to garrison our overseas possessions, to form the nucleus of our first line of defense, and sufficient officers to act as a training corps for our citizen soldiery. It provides for a National Guard, which has admirably earned its recognition as a national institution in the maintenance of internal order and support of the Regular Army in first line defense. But the unique feature of this Act is that for the first time the constitutional right to call upon all able-bodied citizens to defend our country is given concrete expression in the creation of an Organized Reserve to be constituted in time of peace of skeletonized organizations completely officered but with only a few non-commissioned officers and enlisted specialists. In the event of war these Reserve Divisions and Units would form the bulk of our armies. Whether the future war will be fought in our own or the enemy's country will be determined by the rapidity with which we can mobilize our armies, and the success of this mobilization and of the war rests on the trained officer personnel, on the officers of the Regular Army and the National Guard primarily, but more especially, because of their number, on the officers of the Reserve Corps.

The majority of the officers in the Army during the War accepted reserve commissions on their discharge from active service, so that it is possible to make the initial assignment of officers to these units of the Reserve Armies from men who have had experience in war. However, this most valuable asset in national preparedness, this splendid body of war-trained men, will be constantly reduced in number from year to year, until at the end of twenty years they will have to be written off the books entirely. In order to discount this national depreciation in our experienced officer personnel, and to fill the shortages already existing in many of the branches of the service, the National Defense Act provides two principal agencies for obtaining and training Reserve Officers: The Citizen's Military Training Camps and the Reserve Officers' Training Corps.

The Citizen's Military Training Camps, or the C. M. T. C., is an expansion of the Plattsburg idea, and provides for progressive advancement of the more competent men, who upon completion of their third and advanced camp may then be recommended for a Reserve commission. The Reserve Officers' Training Corps, or the R. O. T. C., introduces into our colleges and universities military training alongside of their professional training, so that a man who joins the R. O. T. C. and meets the requirements may, on graduation, be recommended for a Reserve commission. It is but logical that the Government should give special inducements to college men to become officers in the Reserve, for it was abundantly proven, if proof were necessary, that as a group, with their trained minds, their imagination and their ideals, they made the best officers in the War.

Military training in the R. O. T. C. is divided into a basic course during the freshman and sophomore years in which the elementary military instruction, common to all branches, is taught, and an advanced course during the junior and senior years, in which students are given specialized training in the branch of the service which they select, and in which they hope to receive a Reserve commission. Three hours of recitation or drill a week are required in the basic course, and five hours in the advanced course. This may be instruction given directly by the Military Department, or where practicable, by any other appropriate department of the institution under the supervision of the Military Department. In connection with the basic course, a basic camp is authorized, but not required, and because of limited funds, has not as yet been greatly developed. As a part of the advanced course every student is required to go to a special training camp of his branch of the service for six weeks of intensive training during one summer, preferably between his junior and senior years.

As an inducement to join the R. O. T. C., and in compensation for the additional work required, the Government allows the advanced student one ration a day, or its commutation in money, during the period of his enrollment and in pay $1.00 a day during camp, which for the value of the ration during the past year, amounts to approximately $276.00 for twenty-one months they are enrolled in the advanced course. They are also allowed transportation mileage to and from camp, and a uniform allowance of $36. In effect, this amounts to a Government scholarship in military training of over $300.00 for each advanced R. O. T. C. student.

R. O. T. C. Camp, 1922.

Measuring Velocity of 4.7-inch Projectile. Firing 10-inch Gun.

All of the military instruction at an institution is under the direction of an officer of the Army who is designated the Professor of Military Science and Tactics. The officers and non-commissioned officers, who are his assistants, are designated assistant professors and instructors, respectively, and are organized into the Department of Military Science and Tactics, coordinated with the other departments and forming an integral part of the instructing staff of the institution. Conditions at the various technical schools and universities throughout the country vary greatly, but it is believed that the Department of Military Science and Tactics everywhere is becoming more a factor in university life.

The problem of training R. O. T. C. students for duty as future Odnance Officers differs greatly from that of other branches of the service. The training of the combatant arms is, of necessity, military in character, and consists primarily in the study of the art of war, strategy, minor tactical problems, drills, and the technical work of their branch of the service. On the other hand, so closely is Ordnance Engineering related to general industry that graduates of engineering schools in subjects related to Ordnance Engineering are fair material for Reserve Ordnance Officers, with no special training other than the elementary military instruction required of all officers as given in the usual basic course, and the practical instruction in the handling of ordnance given during the six weeks of camp. The policy of the Ordnance Department has, therefore, been to prescribe no basic course for Ordnance, but to accept that of any branch as satisfactory, and to direct its attention to insuring, first, that its students have a high standard of professional training, and, secondly, that in appropriate courses Ordnance subject-matter and problems are introduced to the end that the relation of the subjects studied to Ordnance Engineering may be clearly established in the minds of students.

In order that this purpose might be accomplished, a system of Ordnance credits was established for subjects whose general scope and minimum number of hours of recitation were prescribed. Additional Ordnance credits were allowed for additional work in authorized subjects, and a student required to elect a course including additional work if necessary, which would give him a total of 18 points in Ordnance credits in order to be eligible for the Ordnance Unit. In prescribing the scope of those subjects, which are directly related to Ordnance, an effort was made to indicate such Ordnance problems and descriptive matter as was thought to be pertinent, without jeopardizing the professional value of the subject.

It is the policy of the War Department that within the general programs of training issued by the several branches of the service, the courses of study and the manner of instruction shall be left, as far as possible, in the hands of the Professor of Military Science and Tactics and the officers in charge of units, who are held responsible for the results obtained. The officers in charge of Ordnance Units have had not only to meet very different academic conditions and standards, but also widely differing policies of their professors of Military Science and Tactics, so that training in Ordnance at the several institutions at which we have units necessarily differs greatly.

It may, therefore, be desirable to give a brief outline of the present approved system of Ordnance training at Massachusetts Institute of Technology, the first Ordnance Unit to be established. The basic course is given in the Schedule of Instruction below:

The advanced course for Ordnance students can best be given by quoting directly from the next year's catalogue.

> "MS 28, Advanced Ordnance Open to Students in Courses II, III-2, V, VI-a, X and XV-2, Subject to Certain Limitations."

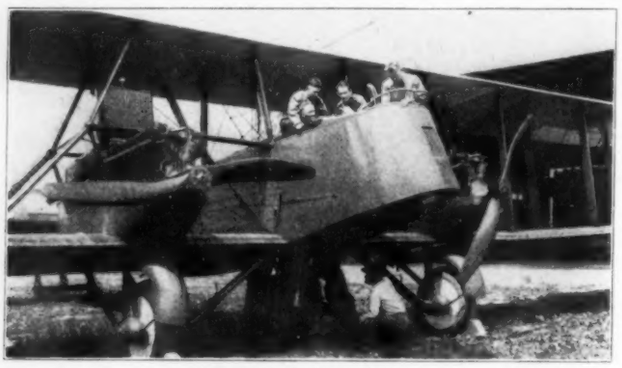
Note.—On assurance that the recommended revision of the regulations would be approved, the courses that would then be eligible for the Ordnance Unit have been indicated, namely: Metallurgy, Chemistry, Electrical Engineering

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS
DEPARTMENT OF MILITARY SCIENCE AND TACTICS — BASIC COURSE 1921–1922 — SCHEDULE OF INSTRUCTION

	WEEKS	1 2 3 4 5	6 7	8 9 10	CHRISTMAS RECESS	11 12	13 14 15 16	17 18	19 20	EASTER RECESS	21 22 23 24 25	26 27 28 29 30
FRESHMEN	C.A.C. ENGR. S.C. A.S. ORD.	INFANTRY DRILL (SCHOOL OF THE SOLDIER, SQUAD, PLATOON AND COMPANY)	MILITARY COURTESY AND DISCIPLINE	HYGIENE SANITATION AND FIRST AID		ORGANIZATION ADMINISTRATION AND SUPPLY	MILITARY LAW AND THE RULES OF LAND WARFARE	MANUAL OF INTERIOR GUARD DUTY	SIGNAL COMMUNICATIONS FOR ALL ARMS (LIAISON FOR ALL ARMS)		INFANTRY DRILL (SCHOOL OF THE COMPANY, CEREMONIES AND DUTIES OF N.C.O.'S AND OFFICERS, FRESHMEN ROTATING IN THE VARIOUS CAPACITIES)	
SOPHOMORE	C.A.C. ENGR. ORD.	SMALL ARMS CARE, OPERATION AND USE (INCLUDES RIFLE, PISTOL, MACHINE GUN, AUTO-RIFLE, GRENADES, TRENCH MORTAR, 1PD. GUN AND GALLERY PRACTICE)	MINOR TACTICS (ADVANCE, FLANK, AND REAR GUARDS, OUTPOSTS, PATROLLING, PORTIONS OF FIELD SERVICE REGULATIONS PERTAINING TO CO. OR BATTERY OFFICER)			FIELD ENGINEERING		MILITARY HISTORY AND POLICY OF UNITED STATES			MAP READING AND SKETCHING	COAST ARTILLERY MATERIEL (GUNS, MORTARS, AND HOWITZERS, AND THEIR CARRIAGES AND MOTOR TRANSPORT)
	S.C.	(DO)	(DO)			(DO)		(DO)			(DO)	SIGNAL CORPS INSTRUMENTS (DESCRIPTION, OPERATION, AND USE, INCLUDING CODE PRACTICE)
	A.S.											GENERAL AIR SERVICE SUBJECTS

Schedule of Instruction.

(specializing in power), Mechanical and Electrical Engineering Administration in addition to the two courses Mechanical Engineering and Chemical Engineering, now authorized. In addition, it will be then possible to secure individual men from Physics and General Science courses who can arrange their schedules to meet the Ordnance requirements.



R. O. T. C. Camp, 1922.
Attaching Bombs to Martin Bomber.

"In view of the intimate relation between the work of the Ordnance Department and general industry, advanced Ordnance instruction is given by introducing Ordnance subject-matter in appropriate subjects of the above courses."

Note.—Instruction by the introduction of Ordnance data and problems in appropriate subjects is a basic principle of the original Ordnance training regulations that has unquestionably proved its value. It offers an almost unlimited field for the ingenuity of the officer in charge of the Ordnance Unit, and, as a rule, the faculty are only too glad to receive suggestions for incorporating Ordnance data in their course that will add to the interest of the work.

In Applied Mechanics, the basic problems encountered in Ordnance design are used to illustrate general principles. In Hydraulics, the hydraulic brake and recuperator are studied. In the Theory of Elasticity, compound cylinders are studied by means of a built-up gun. In Thermodynamics, the gun is treated as a gas engine, in which the piston is not returned, and the heat losses are calculated. In chemical subjects, substances used in the manufacture of Ordnance are identified and their use explained. The relation of chemical processes such as drying, recrystallization and combustion to the Ordnance problem are emphasized. Thermochemistry is studied in its relation to the fixation of nitrogen, and in Chemical Engineering, the plants and appliances used in the manufacture of pyrotechnics, explosives, detonators, nitric and sulphuric acids are studied with particular reference to the production of ordnance.

"Advanced ordnance instruction is given . . . . by special instruction in that phase of ordnance engineering bearing directly on the course the student is following."

Note.—In order to summarize the knowledge of ordnance they have received indirectly in connection with the subjects of their regular course, and to give them a concrete picture of the work they may be expected to do when called into active service, it is believed highly desirable that all Ordnance students be required to take in their senior year a course of special instruction in that phase of Ordnance Engineering for which they are best fitted. The officer in Charge of the Ordnance Unit will assist in this instruction.

In Mechanical Engineering a special option has been arranged for Ordnance students taking the general course, which includes 40 hours of heat treatment, with special reference to Ordnance, and 80 hours of Ordnance Engineering. In the last term the students will be given the design of a gun and carriage. Those students taking the Automotive Engineering option will study the design of a tank or tractor. It is planned to give the Ordnance students taking Engineering Administration a shorter and more general course in Ordnance Engineering, covering the gun-carriage problem. All Ordnance students taking chemical courses will be required to take a special elective in the Chemistry of Powder and Explosives under Professor Davis, one of the best explosive chemists developed during the War. In Metallurgy, Ordnance students will be required to take special elective Metallurgical Plants with 60 additional hours allowed from their thesis time, devoted especially to furnaces and apparatus for the production of ordnance. Full academic credit is given for all of the special Ordnance instruction noted above, except the 30 hours required of students in Engineering Administration.

"Advanced Ordnance instruction is given . . . . by a brief course of general lectures on Ordnance subjects—given by the Ordnance officer assigned to the Military Science Department."

Note.—It is considered especially desirable that all Ordnance students be given a knowledge of the organization of the Ordnance Department, the functions and relations of its major divisions, the activities of its various arsenals, and especially the operations of the Field Service.

There has also been established recently at Massachusetts Institute of Technology the first collegiate post of the Army Ordnance Association, with practically a full membership of all Ordnance R. O. T. C. students and Ordnance officers studying at Technology. Meetings are held and

R. O. T. C. Camp, 1922.
14-inch Plate Penetrated by 14-inch Projectile.

talks given on the latest developments of ordnance. In its capacity as the Society of the R. O. T. C. Unit, it has done much to raise the esprit and promote fellowship among these future Ordnance officers and their older brothers.

The conditions are especially favorable for the development of an Ordnance Unit at Massachusetts Institute of Technology which, for a number of years, has been in intimate contact with the Ordnance Department through Watertown Arsenal. Whatever has been accomplished is due to the splendid co-operation of Professor Miller, head of the Mechanical Engineering Department, himself a Colonel of Ordnance with the Reserve Corps, and the other professors who have entered so enthusiastically into the training of these future Ordnance officers.

The summer camp of six weeks is the principal opportunity for practical instruction, and the Ordnance Department gathers its men from all its units at Aberdeen Proving Ground. Here we have an unusual opportunity for interesting practical work. Not only do the students learn to operate and fire the arms of all branches of the Service, to operate and maintain tanks and tractors, but also to actively assist in the test of new and experimental matériel, and in the regular proving ground operations, such as acceptance tests and ballistic firings.

The camp started on June 15 with representatives from six Ordnance Units, distributed as follows:

Massachusetts Institute Technology, 39; Cornell University, 19; Georgia Institute Technology, 21; Wisconsin University, 5; Michigan University, 5; Yale University, 2. Total, 91.

This year's schedule of instruction is a marked improvement over that of former years, in that the number of lectures has been reduced to the minimum and actual work with the material increased accordingly. The time is also so apportioned that practical instruction is assured continuity of at least three consecutive hours. The students are grouped into sections of eight or nine men to an instructor, permitting the maximum amount of individual instruction and actual operation of the material by the men. College groups are purposely divided, in bunking, mess, and sections, so that full advantage may be taken of our small camp where everyone may know everyone else.

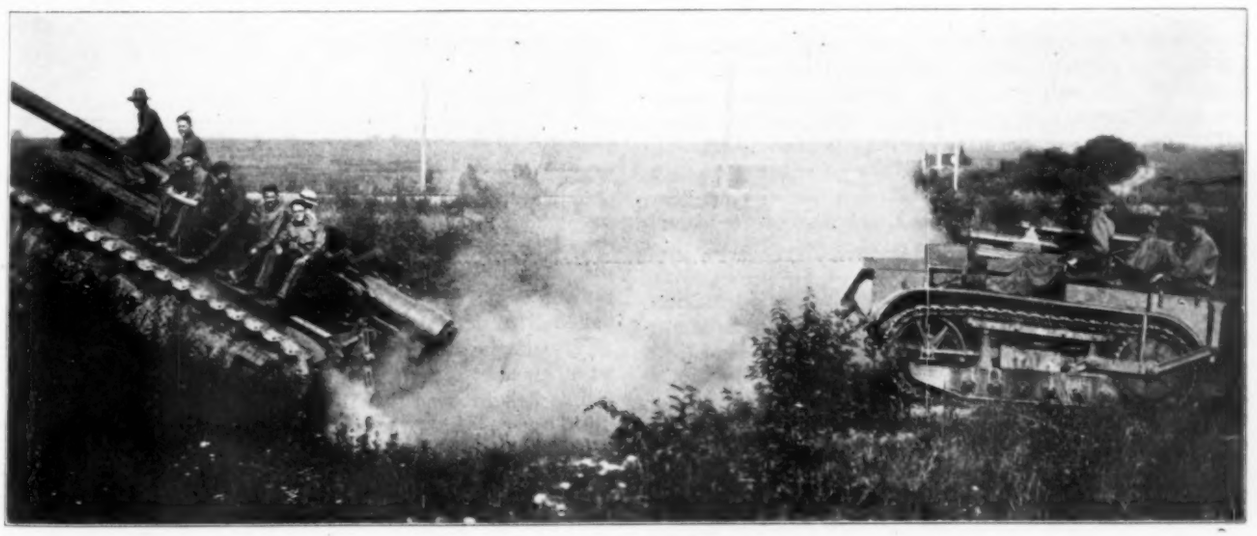
The amount of ground to be covered in the limited time available of necessity leaves little time for organized athletics, which is an important feature of most training camps. However, every student is encouraged to enter into some form of sport, especially swimming. Classes have been formed for those who cannot swim. For those who can swim, the "Buddie System" is in force, and a swimming meet is being organized. Each company has its baseball team, which is now engaged in an exciting "world series." Four excellent tennis courts are available to students, and a tournament is to be held at the end of camp. A nine-hole golf course adjoins the camp. Advantage has been taken of the presence of the captain of the Cornell fencing team to arouse interest in this soldierly sport. The future editors of technical magazines are busy on "The Bursting Bomb," a souvenir book of the camp, which it is hoped will be the first of a long series. The musicians have organized an orchestra that holds forth at the weekly dances, and almost any time in the students' club after dark. Picnics and trips are being arranged for the students who do not avail themselves of the passes over week-ends. Aberdeen is only forty minutes from Baltimore and only one and one-half hours from Philadelphia and Washington. It is believed that this year's camp will be the most successful one that the Ordnance has held and that no camp of any branch can offer more interesting work or more general good time.

In the establishment of its R. O. T. C. Units the Ordnance Department has been greatly handicapped by a shortage of officers with sufficient experience to be placed in charge of units. However, it has established eight units, as shown on the following table, and is planning to establish three more in the near future.

Institution	Date Established	Enrollment of Advanced Students 1921-1922
Mass. Inst. Technology	1919-1920	82
Cornell University	1920-1921	50
Yale University	1920-1921	13
Wisconsin University	1920-1921	25
Georgia Inst. Tech.	1921-1922	29
Michigan University	1921-1922	7
Cincinnati University	1921-1922	....
California University	1922-1923	....
Total		206

It is believed that most of the training of these future Ordnance officers is one of the most important problems of the Ordnance Department. The importance of this task can readily be appreciated when we realize that the Ordnance Department will require for the next war over 5,000 Reserve officers, that of this number we have less than one half now commissioned, that our yearly loss is approximately 150, a number that will increase rather than decrease with years, and that our yearly gain has been but 180, of which 70 have been from the R. O. T. C.

It must be remembered that the Ordnance Department is in keen, though friendly, competition with the other branches of the Service for these trained minds of the country that yearly graduate from our technical institutions. The men of the Army Ordnance Association know our need and can help the officers in charge of Ordnance Units enormously by taking an interest in their nearest unit and in these young Ordnance officers from the R. O. T. C.



R. O. T. C. Camp, 1922.
Self-propelled Mounts Negotiating Sunken Road.

Commercial Tractors for Emergency Use

By

J. B. HANEY

Member A. O. A.

IT is the purpose of this paper to present the results of an investigation of the tractor matériel that would be available for the use of the United States Artillery in case of emergency. Some prominent types are described briefly so their characteristics may be compared with those of the Artillery tractor matériel being developed by the Ordnance Department to haul the Artillery matériel recommended by the Caliber Board.

In the event the United States should be called on to participate in a war of any magnitude in the near future, it is anticipated that the Field Artillery used during the first year would be that used during the World War and that it will be in large part motorized. The weights of this matériel completely equipped, including the limber, are:

	Pounds.
75 mm. Model 1916 U. S.	4,600
75 mm. French	4,200
155 mm. Howitzer (Schneider)	8,900
4.7 inch Gun, M. 1906	9,800
8 inch Howitzer (British)	22,000
155 mm. G. P. F.	23,000

For use with this matériel it is expected that there will be available 1,000 ten-ton and 2,500 five-ton tractors and if certain modifications now being tested prove successful, 110 2½-ton tractors.

As it is expected that these 3,600 odd tractors will all be absorbed by the units of the Army available when war is declared, the Ordnance Department must study the possibility of providing an adequate supply of suitable tractors for training, replacements, and for equipping the motorized artillery units of an expanding army. As it is anticipated that these demands will total approximately forty thousand for the first nine months, the inadequacy of the present reserve of tractors and the urgent need of discovering possible sources of supply of tractors that can be used for military purposes and obtained in sufficient quantities is apparent. The only substitutes available to fill this shortage are the commercial and agricultural tractors which may be in production in reasonable quantities and which even though they fall short of the desiderata of military tractors, are capable of helpful though restricted use with artillery. Such tractors, lacking the road speed desired for strategical movements, would still be useful for short hauls over bad ground near the scene of action.

Of the present military tractors, the 5-ton has a maximum speed of 7½ miles per hour and the 10-ton 6 miles per hour with drawbar pulls of 5,000 and 8,000 pounds at these speeds. The 2½-ton tractor, model of 1918, though designed for higher speeds will, if returned to service, be limited to a speed of 7½ miles per hour and will have a drawbar pull closely approximating that of the 5-ton tractor.

The new tractors being developed by the Ordnance Department are to have a maximum speed of 12 miles per hour and to be able to maintain the same speed as a truck train over any road on which the truck train can operate. In addition, they will be required to handle their normal loads cross-country over terrain impassable to wheeled vehicles. Another requirement is that changes of speed by shifting gears must be made without bringing the tractor to a stop.

Army artillery will travel but short distances off roads. The Corps artillery may be required to travel considerable distance off roads, but time will generally be available to select routes more or less practicable, while the Division artillery will be expected to cross any terrain over which Infantry can attack or defend.

Tests made at Rock Island Arsenal indicate that the worst soil condition at that place, a sandy loam in which 60 inch artillery wheels sank about six inches, offered a resistance to traction on level ground of approximately ¼ pound for each pound of weight of the wheeled vehicle. Such soil would, however, have but little effect on the power required to move the tractor itself.

In addition to the drawbar pull required on level ground, there will be required for ascending grades a drawbar pull equal to the product of the combined weight of the tractor and its towed load multiplied by the sine of the angle of the grade.

The development of tractors to haul the new Division, Corps and Artillery matériel recommended by the Caliber Board, is proceeding satisfactorily. Three types of Division tractors, two designed by the Ordnance Department and one of commercial design, are now being tested at Aberdeen Proving Ground. An Army tractor designed by the Ordnance Department will be ready for test in a few weeks, and later in the year a Corps tractor, also of Ordnance design, will be completed. Even when satisfactory types are developed, it is certain that but a negligible number will be built. Although production plans may be carefully worked out and the jigs, fixtures, and gauges necessary for manufacture prepared, it must be at least nine months after a contract is placed before deliveries can commence and three to four months longer before full production can be reached.

With present facilities, the estimated commercial production of tracklaying tractors per year is approximately 15,000, so it is evident that to obtain the 40,000 required in nine months it would be necessary to increase production and perhaps to use tracklaying tractors with front wheel steer and wheel tractors with or without tracklaying adapters. The production capacity of the tracklaying tractors with front wheel steer is 15,000 per year, but about 80 per cent of this production is of a tractor with a normal drawbar pull of less than 3,000 pounds. The production capacity of the manufacturers of tracklaying adapters for wheel tractors is not known, but as they are comparatively simple it is believed that their production could be brought up to a very large figure in a comparatively short time.

The wheel tractors for which these adapters are built are now being produced at the rate of 200,000 per year. There is also a large production of wheel tractors of larger sizes than the one mentioned, one manufacturer alone producing 50,000 per year.

To give an idea of the characteristics of commercial tractors, a brief description of three tractors by different makers, each adapted to one type of artillery, will be given. Tracklaying tractors only are described, as it is considered that they are the only type that can successfully meet the demands of actual battle conditions. There is also added the description of a smaller tracklaying tractor which is just a trifle under the drawbar pull demanded for division tractor, but which might be used under certain favorable conditions.

(A) A Commercial tractor considered suitable for Army Artillery of present design. Weight approximately 17,000 pounds. It is 141 inches long, 92 inches wide and 77 inches high. Three speeds forward, 1⅞, 2⅝, and 4 miles per hour and one speed in reverse are provided. Drawbar pull at 1⅞ miles per hour is 11,000 pounds. Power is furnished by a 4-cylinder 6½ x 8½ engine, running at 650 revolutions per minute.

The truck frames are steel channels with the track roller pins secured to the bottom flange. Steel plate aprons extending down to the tracks from either side of the frame keep stones and dirt from the track. Just in the rear of the idler sprocket is a spring seat with a helical spring. The equalizing bar connecting the track frames rests on these springs and is pivoted on the body of the tractor at the center.

The track shoes are built up. The links are drop-forged and heat-treated and the shoes are cast carbon steel. These shoes are cast with integral grousers. For work on hard roads pressed steel plates are provided, covering the grousers edges and furnishing a smooth bearing surface of limited area. The sprockets of chrome steel, heat-treated, are driven by internal gears.

The transmission and steering clutches are simple and rugged. All gears are cut from alloy steel and heat-treated. Accessibility has been carefully studied so all parts requiring adjustment can be reached generally with no more trouble than removing a cover. Pistons and connecting rods can be removed through the ports in the crank case and the steering clutches, bevel gear adjustment, transmission gears and main clutch can be examined and adjusted with a minimum of trouble.

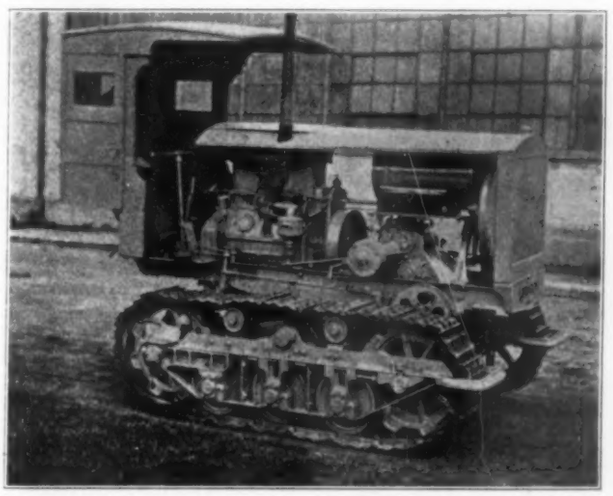
(B) A commercial tractor considered suitable for use with

A Heavy Commercial Tractor considered suitable for Use as an Army Tractor in an Emergency.

Corps Artillery. This tractor is 125 inches long, 66 inches wide, 75 inches high and weighs about 8,500 pounds. Power is supplied by a 4-cylinder 4¾ by 6 inch engine, running at 950 r. p. m.

Three speeds forward, 1½, 2¼, and 3½ miles per hour, and one speed in reverse are provided. When tested at the University of Nebraska this tractor developed 5,800 pounds drawbar pull at 1.3 miles per hour and 3,400 pounds at 2.3 miles per hour.

The track shoes are of manganese steel each provided with two lugs or teeth which engage the teeth on the sprocket. Openings in the shoe between the teeth allow stones or dirt that may lodge in the track to escape.



A Commercial Tractor with Characteristics suggesting its use as a Substitute Corps Artillery Tractor

The drive and idler sprockets have system of shrouding on opposite sides of alternate teeth to prevent derailment.

Each truck frame carries three double rollers of rather large diameter which run in bearings attached to the truck frame. These bearings, similar to those of a railway car, have an oil reservoir that requires filling only at long intervals.

The body of the tractor is supported by an axle which rests in the bearings near the center of each truck frame and by an equalizer bar between the truck frames at the rear. The drawbar, constructed so as to prevent "jackknifing" when descending grades with a towed load, is attached to a crosspiece between the two truck frames to correct tendency of the front of the tractor to lift when towing a load and to make turning easier.

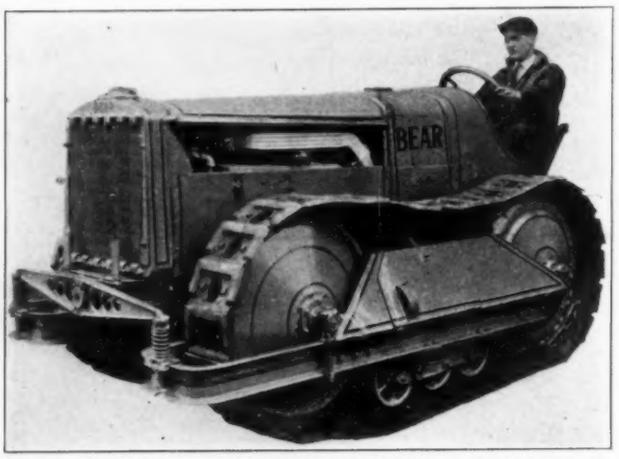
The engine of this tractor is placed in the rear of the transmission, the latter being a separate unit. The drive from the transmission to the track sprockets is through roller chains on each side. The tractor is steered by planetary gears which give a minimum turning radius of 7½ feet.

(C) A commercial tractor considered suitable for hauling Divisional Artillery. The tractor described under this heading is a recent development. This type tractors have had, however, thorough tests and have performed to the satisfaction of the designers who are commencing production on a small scale. From an engineering viewpoint this tractor is rather interesting and is believed to have sufficient worth to justify describing it here.

This tractor, completely equipped, weighs 6,000 pounds. It is 118 inches long, 60 inches wide and 54 inches high. The ground pressure is 3.9 pounds per square inch. Power is furnished by a 4-cylinder 4¾ by 6½ Stearnes engine which develops 49 horsepower at 975 revolutions per minute. Two speeds forward, 1½, 2¾ miles per hour, and one speed in reverse are provided, but the designer says that the tractor can be speeded up to 6 miles per hour without difficulty.

The overall efficiency of this tractor from engine to drawbar is claimed to be 75 per cent; this would give 36.75 drawbar horsepower, or drawbar pull of about 5,000 pounds at 2¾ miles per hour.

The track is built up. Drop-forged, heat-treated rails are secured to the pressed steel shoes by a bolt and dowels riveted to the shoe. The track pins, which are free to revolve in the rails, are of hardened steel with a collar about 1½ inches in diameter, integral with the pin at the center. These pins are placed in position before the trails are bolted to the



A Recent Development suggested for Emergency Use as a Divisional Artillery Tractor

track shoes. Each sprocket tooth when it comes in contact with the pin rotates the pin slightly; this rotation prevents the pin and the pinholes from wearing out of round. An opening at the center of each track shoe allows the escape of ice, dirt or other matter that might derail or break the track.

The truck frames are of pressed steel channel section, pivoted on the driving sprocket axle and enclosing the front idler. T-shaped guides secured near the front of the track frame, which engage in slots in brackets on the body of the tractor, prevent spreading of the track frames. The front end of the tractor is supported by an equalizer bar which turns on a pivot at the center and transfers the load to the truck frames through helical springs at either end.

The three track rollers on each side are connected by equalizers which divide the load equally between the two helical springs shown. Side thrusts are taken on brackets secured to the truck frame.

The drawbar pull is taken from the front end of the truck frames by wire cables which have sufficient resiliency to absorb shock. The rear ends of these cables are attached to a crosspiece on a strut, the front end of which bears in a ball and socket bearing on the tractor body and has a compression spring which keeps tension on the wire cables and acts as a buffer when the tow tends to overrun the tractor. The rear end of the drawbar is supported by chains secured to brackets on the body of the tractor.

(D) There is a fourth type of tractor whose weight and drawbar pull are a little below the empirical limits set on these characteristics but which it is believed would prove satisfactory except under the most adverse conditions.

The tractor weighs approximately 4,000 pounds, is 103 inches long, 52 inches high and 48 inches wide. The track shoes are 10 inches in width and with 51 inches of track in contact with the ground, the pressure is 4 pounds per square inch. The tractor is composed of but three units, the trucks with the track, the motor and the transmission.

The track shoes are of cast carbon steel, heat-treated. The pin hole in the shoes are fitted with a hardened steel bushing. On this bushing is a tempered spring steel roller, free to rotate. The pin which passes through the bushing has a square head and is held in place by a cotter pin through lugs in the shoes.

The truck frames are of pressed steel with an apron which is a part of the frame extending down close to the tracks to prevent dirt and rocks from getting into the track.

The truck frame is secured to the tractor body by a link connecting it to an axle extending through the body. Between the axle end of this link and the truck frame is a heavy rubber pad to prevent shock and damp vibration. When the track is loaded the body of the tractor is lifted relative to the truck by the toggle or "jack-knifing" action of the link, of which the center at the front or truck frame end is slightly lower than the center of the axle through the body. There are three cast-iron track rollers with chilled flanges in each frame.

The transmission gears are of heat-treated alloy steel. The tracks are driven through steering clutches with brakes for quick turning.

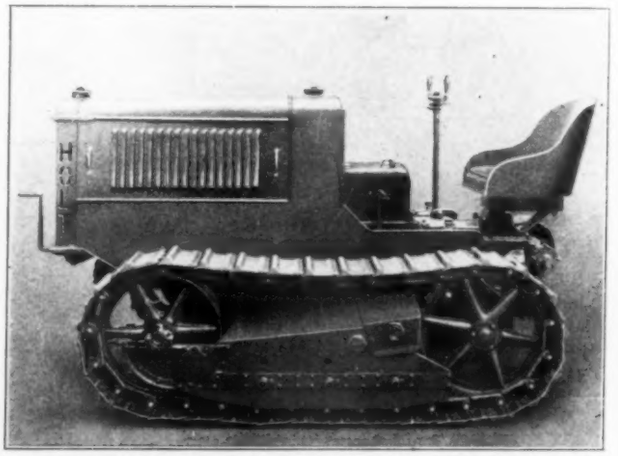
The final drive cases are completely closed except when the sprocket shafts pass through and this joint is made dust and water tight. All working parts are housed but readily accessible.

The engine designed and built by the Hall-Scott Co., has 4 cylinders, 4 by 5½, and runs at 1,100 revolutions per minute. It has an overhead camshaft of rather unique design in that both the inlet and exhaust valves are operated, by means of wipers, by the same cam.

This tractor has three speeds forward, viz, 2⅛, 3, and 5¼ miles per hour, and reverse. Drawbar pull at low speed is 2,600 pounds; at 2nd speed, 1,850, and at high speed 1,100 pounds. By increasing the speed of the engine, somewhat higher speeds may be maintained. One driver reports making a run of 38 miles in 6 hours over ordinary roads. A favorite stunt of demonstrators is to run this tractor off a truck, allowing it to drop to the ground.

Tractors of this size can be used where both the tractor and artillery can be hauled in trucks to points on roads as near as practicable to the scene of action, there unloaded, and the tractors used to haul the artillery to the selected positions.

The true worth of any tractor for service with the artillery can only be determined by test. Such tests are made by the Ordnance Department—(*a*) to determine the limitations of the type when used for hauling artillery; (*b*) to obtain engineering data and (*c*) to obtain such information



This Commercial Tractor would be found very useful for Divisional Artillery though Weight and Draw-bar Pull are less than are desirable

as possible in a brief test as to the reliability and durability of tractors of the type tested.

If this Ordnance Department test indicates that a tractor possesses sufficient merit, it is then issued to the using service, the Field Artillery, for a service test, and on the results of this test it is accepted or rejected.

The Ordnance Specialists School

By

SAMUEL R. KIMBLE

Member A. O. A.

PRIOR to the beginning of the late War, the training of Ordnance Enlisted Personnel for Maintenance Work had been considered only in a general sense; in fact, so little maintenance work on Ordnance matériel was performed by the enlisted personnel of the Ordnance Department that the need of such training was not fully appreciated. However, the developments which occurred during and after the War brought about an entire revolution in conditions which make such training necessary. Ordnance matériel has been increased in type and quantity and the increase in the number of types has been carried to such an extent that specialized instruction has become imperative. As a result of these changes, a study was made of the methods necessary to properly train men for maintenance work in the field and, while this study was not completed during the War, such progress was made that at the close of the War the Ordnance Department was possessed of a Special Service School, well equipped and well organized to carry on this work. Further study was necessary to adapt the organization and methods of training to peace-time conditions and co-ordinate the objectives of the school with the actual need of the Maintenance Branch of the Field Service Division.

The school was established at Raritan Arsenal and was known as the Ordnance Operation, Maintenance and Repair School. At the time of re-organization the name was changed to the Ordnance Specialists' School, which designation it now bears.

The object of the Ordnance Specialists' School is:

(1) To train enlisted men of the Ordnance Department for specialist ratings specified in the Tables of Organization.
(2) To train qualified specialists for the higher grades in the Ordnance Department non-commissioned staff.
(3) To train such officers of the Ordnance Department as may be ordered to the School for instruction.
(4) To train such officers and enlisted men of the Line or other branches of the Service as may be ordered to the School for instruction.
(5) To train officers and enlisted men of the Reserve Corps and National Guard in accordance with opportunities which may be presented from time to time.

The training of Ordnance Enlisted Personnel is along such lines as will best fit them for Ordnance Supply and Maintenance Work in the field and better enable them to take their proper positions in the Ordnance companies to which they are assigned. This training is not intended necessarily to fit a man for a position in civil life, but primarily to enable him to render better service to the Government. If, however, at the same time, the soldier is able to fit himself for a better position, in case he should desire to leave the service at the completion of his contract, every opportunity is presented for so doing. Under existing regulations the right of the Government to a just and fair return for the expenditure necessary in the instruction of the soldier is recognized. The requirements for entrance to all special service schools provide explicitly that the soldier must have at least one year to serve on his current enlistment after he would normally have completed the course to which he is to be assigned. The policy of direct return of the graduate to his organization is one which is to be insisted upon, not only by the school authorities, but by the Office of the Chief of Ordnance, for only by the adoption of this policy and the rigid adherence thereto can cooperation between the Organization Commander and the school authorities be effected. It is believed that if an Organization Commander is assured the student will be returned to his organization at the completion of the school year greater care will be exercised in selecting men for this detail.

Such training as it is contemplated to give an Ordnance officer at this school is with a view of specializing him in the duties incident to the command of an Ordnance company.

The training of enlisted men of the Line and other branches of the Service is along such lines as are laid down at the time of their assignment and in accordance with the wishes of the Chief of the Branch to which they belong. Special efforts are being made to familiarize such students with Ordnance systems and procedure and promote a spirit of co-operation between the Ordnance Department and the Line.

The Commandant of the School is a Field Officer of the Ordnance Department and is directly responsible to the Chief of Ordnance, through the Chief of the Recruiting and Training Section, for the general administration of the school. He is aided in this work by the Assistant Commandant who, under the supervision of the Commandant, is charged with the administration of all training activities of the school within the scope and extent determined by the Faculty Board and by a staff of qualified instructors, commissioned, enlisted and civilian. The enlisted members of the staff, with one exception, are all graduates of the school. The Faculty Board is made up of the Commandant, the Assistant Commandant, the Secretary and the Directors of Departments. The functions of this Board are two-fold: first it acts, in an advisory capacity only, on such matters relative to the school as may be referred to it by the Commandant; second, it determines all matters relative to standing, rating or classification, proficiency or deficiency of students and, in matters of this nature, the majority ruling of the Board is final.

Students are ordered to the schoool from the various posts in the country for courses of instruction, upon the completion of which they are returned to their proper station.

The school is divided into three main departments, namely: Trades, Armament and Automotive.

The Trades Department embodies the Machine Shop, Blacksmith's Shop, Carpenter's Shop, Electrical Shop, Sheet Metal Shop and Welding Shop.

The Machine Shop is equipped with modern machinery of all types, including thirty 9-inch screw-cutting lathes, two 18-inch lathes, one 24-inch lathe, two 12-inch lathes, two 14-inch lathes, four 16-inch shapers, six Browns and Sharpe Universal Milling Machines, several types of inter-

nal and external grinders, heavy-duty Cincinnati milling machines, planers, shapers, radial and upright drill presses, an Olson testing machine and a complete equipment of small tools, jigs, calipers and measuring instruments.

Most of this machinery is operated with individual motor drive, although some of the larger machines are belt driven.

In the blacksmith shop there are twenty forges for instruction purposes, two heavy-duty forges with motor-driven blowers, Bradley helve hammers, hardening furnaces and baths. An air compressor is installed with a capacity capable of furnishing compressed air to the entire building.

Trades Department

The carpenter shop is furnished with a complete sawmill, band saw, rip-and-cut-off-saw, planer, edger, lathe and a complete line of carpenters' tools.

The sheet metal shop has a complete line of sheet-metal working tools, both power and hand-operated.

The Electrical Section is equipped with electrical instruments and appliances of all descriptions necessary for instruction purposes. This section is charged with the care and maintenance of the electric machinery and installation in the school building. This installation is considered a portion of the instruction matériel for this section.

In the Welding Shop are five complete electric arc welding sets, one electric spot welder and sufficient gas welding equipment to accommodate all students who are assigned to that course.

In the Trades Department men are taught to be Machinists, Machine Operators, Blacksmiths, Carpenters, Electricians, Toolmakers and Welders.

The Machinist Course gives the student a comprehensive idea of general work as applied to the needs of the Enlisted Personnel of the Ordnance Department. He is instructed in the actual use of machine and hand tools, their care and preservation, and in the use and operation of the equipment. Shop arithmetic and general lectures form a part of the course. The extent of the training received in this course is as follows:

Bench and Lathe Work. This subject covers the nomenclature, care, use and preservation of tools. Lectures on these subjects are given and the student is required to do certain exercise work consisting of chipping, filing, surfacing and sawing, etc.

Planer and Shaper Work. The various kinds of planer and shaper work, including keyway cutting, planing with dividing head and rack cutting come under this subject. Lectures are given on the different types of machines and their operation, and certain exercise work is required.

Drill Press Work. At this point in the course lectures are given on the operation of the different drilling machines and equipment and the student is taught to lay out work and drill in various metals. A portion of the time is devoted to lectures on drilling and boring operations and particular stress is laid on the proper care of the equipment.

Lathe Work. Considerable time is spent on this subject because it is believed that a thorough knowledge of lathe operation will form a foundation for success on other machines studied later in the course. The instruction work consists of lectures on the care and operation of the lathe and exercise work embodying all lathe operations such as rough turning, taper turning, thread cutting, drilling, boring, reaming and finishing.

Milling Machine Work. In this class of work a special study is made of the equipment and the classes of work which it will perform. Lectures are given and extensive exercise work such as laying out, drilling, reaming, plain milling, form milling as well as simple, differential and compound milling.

Grinders. The major portion of the time on this subject is spent in the grinding of simple work to close limits in order that accuracy may be attained.

Lectures are given on measuring instruments, as well as instruction on tool-post grinders, internal and external grinders and tool grinders.

During the latter part of this course the time is given over to general repair work. This is not a continuation of the work previously covered but is given with view of affording opportunity for the practical application of theories learned during the course.

This course fits a student to handle machine work in a Maintenance Company.

The Machine Operators' Course is intended for cases where men do not have the necessary qualifications to make general machinists, whose time is limited or for cases where special qualifications are required. Instruction is given in the care of hand and machine tools in general, and those who complete this course are fitted for work on more or less of a production basis.

The Blacksmith's Course furnishes the necessary training to do blacksmith work incident to a Maintenance Company. The structure of the various grades of steel is taught and instruction in forging, welding, tool-forming, hardening, brazing and the working of alloys is given. The extent of the training offered by this course is as follows:

Forging and Forming of High and Low Carbon Steel. Lectures are given on the care of fires, and on the forging and forming of low medium and high carbon steels. Exercise work is furnished, consisting of drawing out rough stock, forming of hooks, bolts, nuts, rings, chain links, etc.

Welding of Low Carbon Steel. Immediately following instruction on the forging and forming of high and low carbon steel, lectures and exercise work in the preparation of stock and in the heating and welding of low carbon steel are given. Such work as welding rings, chain links, lap welds, butt welds, angle and tee welds are turned out.

Toolmaking. In this course considerable time is devoted to the making of tools. The student is given lectures as well as demonstration and exercise work in the forming and tempering of such tools as are used on lathes, shapers, boring mills, etc., and is taught to make chisels, punches, blacksmith tongs, hammers and other hand tools.

Brazing. The instruction under this subject consists of lectures on the structure and properties of cast and malleable iron and exercise work in brazing in the forge.

During the latter part of the course the time is devoted to repair work of a general nature. This supplies an opportunity for the practical application of the knowledge gained during the instruction period, and a point is made to handle some of the repairs which would be met with in a maintenance company in the field.

The Tool Makers' Course is intended for men who have already had the machine course described above. Students are given lectures on the care and use of precision instruments and their use in connection with bench work where they are required to generate base plates, angles, etc. They are given instructions in precision lathe and milling work, gig, die and fixture work and in the forging, hardening and tempering of tools.

In the Welders' Course instruction is given on operations with gas and electricity. Subjects covered are as follows:

Oxy-Acetylene Welding. Instruction is given on the nomenclature and use of the apparatus. Composition and structure of the different metals is covered by lectures and exercise work is given in welding, brazing, soldering and sweating. At the completion of this portion of the course, instruction is given in preheating, and its effects, the welding of preheated castings of various kinds, and the operation of the cutting torch. Practice work in cutting is given for the application of the principles learned in the lecture and instruction work.

Electric Welding. This subject embodies lectures on the operation and construction of electric welding apparatus, instruction in the uses of the various pieces of apparatus and practical exercise work in arc, spot and butt welding both simple and preheated.

During the latter part of this course an opportunity is afforded by general repair work for practical application of the knowledge gained during the course.

Upon graduation from this course a man is considered fitted to handle the welding work which would ordinarily be met with in a Maintenance Company.

The Woodworking Course gives a working knowledge of general carpentry as applied to the needs of the Service. It is not the intention to make a finished carpenter or cabinet maker but merely to fit the student for the minor carpenter work, general repairing and limited amount of framing work incident to the Service. The scope of this course is:

Benchwork. Instruction in the proper use of hand tools, especially those used in sawing, planing, boring and mortising, is given and attention is called to the methods of selecting and sharpening tools. Lectures are given and exercise work is required which calls for the use of common bench tools.

Turning. When the student has completed the instruction work prescribed under the subject of benchwork, he is able to undertake woodturning of various kinds. Lectures are given on the care and operation of lathes and the turning out of various types of work. Exercises required include turning between centers, face plate work and polishing.

Framing. In connection with this course lectures on the construction of buildings and the cutting of sills, studding and rafters are given. Sections of buildings are actually constructed and it is possible to put into actual application the theories gathered from the lectures.

Cabinet-making. At this point in the course, if it is considered that the student has made considerable headway and gained a fair knowledge of general carpenter work, some exercise work in cabinet-making is given, the chief aim being to teach him to make joints and fitments which are not covered in general carpenter work. Lectures are given in cabinet-making and woodcarving.

At the close of the course an opportunity is given for getting some general experience in all kinds of woodworking by setting up frame work, applying inside and outside finish, hanging and fitting doors and windows and making furniture.

The Electrician's Course is laid out with a view to preparing a man to take charge of the maintenance of Ordnance electrical equipment in the field. The instruction given is such that he will become proficient in the practical electrical work necessary on the various pieces of equipment of a Maintenance Company. This course covers the following subjects:

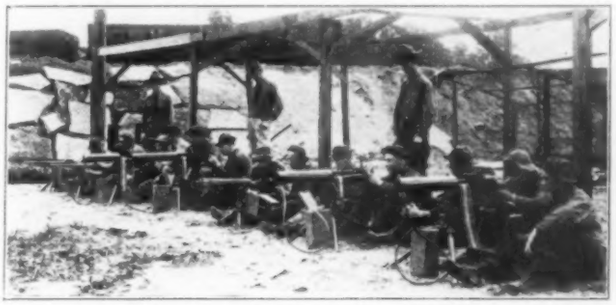
Elementary Electricity and Magnetism. The time spent on this subject is devoted to the study of elements of magnetism, electric currents, laws and rules governing the elements of magnetism and electric currents.

Simple Direct Currents. The study of this subject consists of lectures on simple direct currents and problems in which practical application of the rules and laws explained in the lectures is necessary.

Complex Direct Currents. Lectures and problems are given involving rules pertaining to complex direct currents. The practical work consists of making connections for circuits.

Electric Wiring for Light and Power. Lectures are given on the installation of wire, wiring tables and the figuring of wire sizes. The major part of the time is spent in actual work where experience is gained in doing wiring of all kinds for light and power.

D. C. Generators. In the study of generators considerable time is spent in the study of the construction and wiring of the different types of generators, power required for operation, output and care. Sufficient time is spent to teach the proper method of detecting short circuits, grounds, open circuits and other similar troubles.



Armament Department. Range Work.

D. C. Motors. As the basis instruction on this subject is similar to that on D. C. Generators the work will be along practical lines—location of motor troubles, general operation and speed.

Switchboards. Lectures are given on the construction and wiring of Boards for power plants, storage batteries and motors. Blueprints are furnished and actual experience is gained in the erection and connection of various types of boards.

Measuring Instruments. At this point in the course, the student is capable of undertaking the study of various kinds of measuring instruments which involve the voltmeter, ammeter, wattmeter and testing sets. Instruction work includes the operation of these instruments and their connection with circuits.

The Armament Department includes the Artillery Section, Small Arms and Machine Gun Section, Leatherworkers Section and Explosive Section.

In the Artillery Section will be found a sample of a complete machine shop, mounted on trucks and trailers, for use in the field, as well as all classes of Artillery from the 3-inch Trench Mortar to the 8-inch Howitzer, including all accompanying vehicles and sighting equipment.

The Small Arms and Machine Gun Section is equipped with a considerable number of each type of Machine Gun in use in the Service, as well as a number of foreign and obsolete types of arms and equipment which have been assembled for the School Museum.

In the Leatherworkers Section will be found all classes of leatherworking tools necessary for the instruction of students in maintenance work on leather equipment used in the Service, also with power and hand operated sewing machines of the types issued to the Ordnance Department.

In the Explosive Section there are samples of all types of shot and shell, fixed ammunition, sectionalized fuzes, primers and other explosive matériel.

In the Armament Department men are trained as Artillery Mechanics, Small Arms and Machine Gun Armorers, Leatherworkers and Explosive Specialists.

The Artillery Mechanics Course furnished training in Artillery and Trench Warfare Matériel, ropes, rigging and tackle so that the student can successfully handle this type of work in the field. General lectures and detailed instruction are given on nomenclature, dismounting, assembling and the functions of the various mechanisms.

A part of the time allotted to this course is spent in the Machine and Welding Shops where instruction in elementary bench work, tap and die work, drill press work, lathe,

milling machine and grinder work is given—this with a view to giving the student the knowledge necessary to enable him to handle tools and operate the equipment necessary for the maintenance and repair of Artillery matériel. Sufficient instruction in welding is given, along the lines of brazing, soldering and sweating, to cover all repairs of this nature which would ordinarily be met with on Artillery

Automotive Department.

matériel in the field. Other subjects covered in this course are:

Ropes, Rigging and Tackle.. Particular important is attached to this part of the instruction because of the necessity of a thorough knowledge of the maintenance of rigging and tackle and the ability to tie the various knots prescribed in the Service.

Guns, Howitzers and Mortars. Lectures on the history, theory of development in construction, and the purposes and uses of the different classes and types of Artillery materiel are given; also instruction on guns, howitzers, mortars and carriages. In this way a general knowledge is acquired of all classes of artillery, their nomenclature, action, construction and maintenance.

Battery-Accompanying Vehicles. Special instruction is given on the location of the equipment of each truck and vehicle. While these vehicles are a part of Artillery materiel and are treated under that subject their nomenclature, construction, equipment and maintenance are treated separately, by way of intensive instruction, at this point in the course.

Fire Control Instruments. Nomenclature of the principal parts of the instruments is the main point to be emphasized under this subject. The function and adjustment of the pieces is learned by practical application of certain instruments in the field.

Artillery Repair Truck. The time on this subject is devoted to a study of the capacity of the shop rather than its operation.

A certain portion of the course is given over to actual field experience. Different units of matériel are taken into the field and the student is required to construct gins, shears or spars for dismounting the guns or other pieces of matériel. The student is required to prepare, put in position and use the tackle required for this work. This part of the work is given very careful consideration as the success of a first class specialist depends, to a great extent, upon his ability to construct the necessary apparatus and upon his accuracy in using it.

In the Explosive Section an opportunity is afforded for learning the classification, physical properties and identification of ammunition and explosives used in the Service.

The Small Arms and Machine Gun Armorers Course is given on the development of the various models of Small Arms and Machine Guns in general and particularly those now in use in the Service, together with their equipment. Detailed instruction is given on the operation and mechanism of the different arms adopted by the Service, this with view to fitting the student for handling the maintenance and repair work on all standard guns and equipment.

A portion of the time laid out for this course is spent in the Machine and Welding Shops, where instruction is given in elementary bench work, chipping, filing, hand drilling, peening, tap and die work, lathe and drill press work, etc. In the Welding Shop general instruction is given in Welding, Brazing and Soldering. Other subjects covered in this course are:

Machine Gun Carts and Equipment. This subject covers detailed instruction on the arms now in use in the Serivce including nomenclature, assembly, disassembly, action, stoppages and malfunctions. This instruction affords a thorough knowledge of the operation and function of the guns so that the finished specialist is able to handle field repairs and reduce to a minimum stoppages and malfunctions. Instruction is given on the maintenance and care of Gun Carts and their equipment with a view to giving the student a working knowledge of these pieces which will enable him to make any ordinary repairs in the field.

Small Arms, Hand Arms, and Equipment. General instruction is given on this material and is later followed by detailed instruction of their adoption by the Service. Comparison with obsolete pieces is made which shows the change in development, construction, rate of fire, and muzzle velocity.

37 mm. Gun, Carriage and Equipment. Instruction on this gun is given in detail. It includes dismounting and complete disassembling of the piece with its carriage and recoil mechanism as well as the nomenclature and action of the piece.

The range work connected with this course is very important. The student operates the various guns and is given immediate action practice to make him quickwitted and accurate in his decisions concerning the action of the gun. This practice on the range is given at three different times in the course, the time of practice being determined by the ground covered and material studied.

At the end of the course an opportunity is given for the practical application of the knowledge gained by actual repair work on unserviceable guns of different models—cleaning, repairing and preparing them for service or for storage.

The Leatherworker Course gives instruction in laying out, cutting, finishing and repairing leather material used in the Service. Repair work on canvas and web is touched on in a general way.

A certain portion of the time is spent on a general study of leather and particularly its manufacture, tanning and grading. Instruction is given in the preservation of leather and particular stress is given, at this point, to seeing that the student realizes the importance of this subject. Preparation of leather for storage, the conditions under which it should be stored and field conditions are covered in detail.

A study is then made of the nomenclature, care and preservation of all tools and equipment necessary to a leather worker.

Economy in cutting, care in stitching, and special attention to the size and position of stitches is taught.

At the end of the course a short period is spent in learning the nomenclature, adjustment, operation, care and preservation of the standard makes of sewing machines, both hand and power operated, which are used for machine work.

The Automotive Department embodies the Automobile Section and the Tractor Section. It is equipped with all types of motor vehicles, tanks, tractors, etc., that are used in the Service at the present time, including the most recent developments of this type of matériel; a complete line of small tools for the use of students in this department and also a complete line of all special tools peculiar to the matériel in this department. Electric and water dynamometers are installed for testing motors on the block.

In this Department men are trained in the maintenance and care of motor equipment, including the tanks, tractors and self-propelled gun mounts used in the Service.

In the Auto Mechanic Course, instruction is given in the underlying principles of the operation and maintenance of

automobiles and motor trucks. This course fits a man for maintenance and general repair work. The early weeks of the course are spent in the Machine, Forge and Welding Shops where instruction is given in elementary bench and machine work on ordinary welding, forging, hardening and tempering, and in the welding shop general instruction on gas and electric welding is given with a view to teaching the kinds of welding work that can be done successfully. The extent of the training received in this course is as follows:

Chassis Assembly. Lectures are given on automotives in general, spring suspensions, transmissions, axles and steering gears, as well as practical work on the dismantling of chassis on the different vehicles in use in the service.

Motors. This subject is covered by a series of lectures on engines of all types in general and gasoline engines in particular. Practical work consists of observation and work on Holt, Buda, Wisconsin, Packard, Dodge, Ford, Cadillac and Liberty motors. The development of the gasoline is covered, as well as the important points on valves, valve-timing, and lubricating systems.

Carburetors. In covering this subject, attention is paid more to the construction, design and principles of operation of the different types than to the running and adjustment. Intensive instruction is given on pressure, gravity, and vacuum, and gasoline feed systems.

Instruction on ignition is first given in a general way and the more important details of ignition systems are taken up by means of sectionalized equipment. Lectures are given on the elements of electricity and induction as applied to ignitions and practical work is given in tearing down and re-assembling magnetos and other electrical units.

Starting and Lighting Systems. The instruction given is general so that the student becomes acquainted with the principles of the systems and is able to locate points of weakness and causes of failures which most frequently occur. Practical work is given in setting up and operating typical systems on bench and car. Tests are made for grounds, short circuits, etc.

Storage Batteries. Instruction is given on the storage battery cell and the elementary chemistry of action. Demonstration and practice work is given with a view to showing how to recharge batteries, the evils of over and under-charging or charging at too high a rate. Batteries of different types are dismantled and assembled.

General repair work gives opportunity for the application of knowledge gained during the course. Driving instruction offers a chance to gain experience in remedying the common road troubles, driving according to traffic regulation and in convoy.

In the Tractor Mechanic Course, instruction is given in the care, repair, operation and maintenance of tractors in general, and particularly those used in the Service. A part of the time in the early part of the course is spent in the machine shop where instruction is given on the names and uses of tools, both bench and machine, common to tractor work. In the Forge Shop the student gets a working knowledge of ordinary forging, welding, hardening and tempering. In the welding section general instruction on simple welding is given and the kinds of work that can be done most successfully are pointed out. Other subjects covered in this course are:

Frame Assembly. Instruction is given on frame assemblies and especially on the requirements for weight, strength and durability. The absence of delicate adjustments and other features which might cause failure or delay are especially noted as not common to tractors. Practical work is given which consists in dismantling the various models and in the ability to identify the features of construction, and the proper sequence of dismantling in the shops and field.

Engines. This subject is taken up by a series of lectures on engines in general and gasoline engines in particular, as well as valve-timing and lubrication. Practical work is given on Holt, Packard, Dodge, Ford and Liberty motors—stress being placed on lubricating and valve-timing.

Carburetors. Instruction is given on the construction, design and principles of operation of the different types of carburetors, rather than on the running and adjustment. Explanation is made of pressure, gravity and vacuum, and gasoline feed systems.

Ignition. This subject is first handled in a general way and the more important details are taken up by means of sectionalized equipment. Lectures are given on the elements of electricity and induction as applied to ignition systems. Practical work is furnished in the tearing down and reassembling of magnetos and other units.

The latter part of the course is devoted to repair work in the field where the student gets an opportunity for actual application of the knowledge gained during the instruction periods.

For advanced specialists, opportunity is afforded for one to qualify as a Toolmaker, or for the Depot, Ammunition or Maintenance Companies. In the Advanced Specialist Courses it is the policy to admit only graduates of one or more of the Specialist courses described above, or men having equivalent qualifications. While these courses cover similar subjects they are treated from the standpoint of theory rather than practice.

Military Instruction is given to the entire Student body of the School. This instruction consists of Close Order Drill, including Manual of Arms, School of the Company, Bayonet Drill, Small Arms Target Practice, Lectures and Study covering customs and courtesies of the Service, as well as Army and Ordnance Regulations.

Academic Instruction consisting of Arithmetic, Algebra, Grammar and Spelling for the Specialist Courses and Algebra, Plain and Solid Geometry, Elementary Physics and Trigonometry for the Advanced Specialist Courses is required of all students who pursue the regularly prescribed course in any subject.

Regular courses extend from September 1st to June 30th. However, Special Courses, for periods of weeks or months or for lesser period than the length of time regularly prescribed, can be arranged for special types of work or for emergencies which occur from time to time.

All students who successfully complete a course of instruction are given a Certificate of Proficiency.

This School was established at an outlay of approximately $3,500,000, and today stands as one of the best equipped institutions of its kind in the Country. It offers unlimited opportunities for learning a trade or completing an education.

Experience during the World War showed the great desirability of centralizing the work of training enlisted men for the Ordnance Department, both in time of peace and in war. It is not only much more economical in money and in effort but also very beneficial from the psychological standpoint. The element of competition can be introduced to greater effect and individuals who are lagging behind can be segregated for special training to greater advantage.

The somewhat central position of Raritan Arsenal relative to the industrial sections of the country renders it the logical place for carrying on this work. It would be impossible to find a place with better transportation facilities both by rail and water.

It is the intention of the Department to continue the development of the Ordnance Specialists School along the lines already laid down, keeping it abreast of the best similar civilian institutions. It can be rapidly expanded in the event of war and in such emergency will become the centre to which promising recruits will be sent from the country at large and from which trained enlisted Ordnance specialists will be supplied to the Army both individually and by organizations.

The Problem of Exterior Ballistics

By

ALBERT A. BENNETT

THE art of applied exterior ballistics has flourished from earliest times. The boulders which rolled down the mountainsides to crush strangers or hostile marauders as they traversed narrow passes are the historical prototype of the modern airplane drop bomb. (See Plate, Fig. 6.)

The smooth pebble, hurled at the approaching figure of an opponent, was chosen for its high density; and its point of impact was selected with all the skill available. The keen-pointed javelin was designed in partly "stream line" form, and given an acute "ogival" angle to secure the maximum penetration. The initial velocity in every case was made as high as the warrior's good right arm could deliver it.

Exterior ballistics deals with the path of the projectile in air, and is not primarily concerned with the original source of energy, or the manner in which this energy is imparted to the projectile. Ballistically, except in the magnitude of the quantities involved, there are few distinctions to be drawn among the following: The stone flung by hand, the pebble thrown by sling, the boulder fired by cannon, or the pea of the pea shooter and the ball of the old-fashioned musket.

The javelin, arrow, cross-bow bolt, blow dart, modern elongated shell all have much in common. (See Figs. 1-10.) The principal new element in exterior ballistics is the spin of the projectile, resulting in increased stability and thus preserving head-on motion. (See Plate, Figs. 12, 13.)

From shadowy antiquity warriors have distinguished for practical purposes between the flat trajectory of "direct fire," where the projectile traces approximately a straight line, and the cases of higher angles of departure. For ranges too great to be attained at the given velocity and with the given projectile by methods of flat fire, one had only to aim upward and count on the projectile finally falling downward again. The old ballisticians distinguished three parts of the path as suggested by the figure on Plate, Fig. 14. The first part, AB, they regarded as straight. Later, at B, the projectile was supposed to start curving down on an arc of a circle, BC, and finally at C the path, they thought, straightened out until it reached D, the point of impact. This theory was entirely adequate for securing hits and measuring clearances, such as when firing over a heavy battlemented stone wall into the courtyard within.

Such was the state of things when theorists first began reducing laws of motion to mathematical form. The case in which one ignores the retardation of the projectile occasioned by air resistance was completely solved by Galileo on the basis of laws verified by dropping balls from the leaning baptistery tower at Pisa. Balls of different sizes were dropped together. While, according to Aristotle, the time of fall should be inversely proportional to the weight, Galileo demonstrated that the time was nearly the same for great differences in size and weight.

The case in which air resistance is disregarded was much more important formerly than now, since in the first place, our present muzzle velocities are so great as to result in quite violent resistance by the air to the forward motion of the projectile; and in the second place, the increased mechanical accuracy of our equipment renders a moderate percentage error due to computational methods no longer tolerable. See Plate, Figs. 15-17.

Treating the trajectory as a problem in the mechanics of a particle moving through a resisting medium, one is led to write down certain relations involving such quantities as

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EXPLANATION OF PLATE

1. Javelin head; brass.

2. Arrow head; stone.

3. Cross-bow bolt; iron.

4. Malay blow-dart; *a*, wood; *b*, paper.

5. Modern small arm projectile; cupro-nickel jacket, lead core.

6. Air-plane Drop Bomb. These appear much like torpedoes, but have no propulsive or steering device; *a*, fuze, to explode on impact; *b*, cigar-shaped body, containing explosives; *c*, fins, to direct and steady the flight.

7. Projectile head, for penetrating armor. Obsolete for large calibers.

8. 9. Types of projectiles fired in earlier experiments.

10. Modern type of projectile.

11. Section of modern armor-piercing projectile; *a*, air space; *b*, wind-shield, to give better air penetration; *c*, armor-piercing cap; *d*, projectile proper; *e*, explosive.

12. Spinning Top (Asiatic model); *a*, iron ring to increase moment of rotation. Gravity is the upsetting force counterbalanced by gyroscopic action and the friction at the peg. The theory of the top applies also to the rotating projectile. See next figure.

13. Rotating Projectile: *a*, direction of air resistance; *b*, "rotating band," which engages in the rifling, and gives the projectile the proper spin. Air resistance is the upsetting force, counterbalanced by gyroscopic action and "skin friction."

14. Early idea of a trajectory. AB and CD are straight. BC is a circular arc.

15. Trajectory of .30 caliber bullet. Compare with Fig. 17. For the small caliber projectiles the maximum altitude attained is not sufficient to decrease the air density greatly. The higher the angle of elevation, the longer the projectile is in the air and subject to retardation. At something less than thirty degrees, the gain in range which would result in a vacuum by increasing the elevation is, in the air, counterbalanced by the increase in retardation due to longer time of flight. The Siacci methods applied to pistol fire gives quite ridiculously exaggerated values for the maximum range.

16. Comparison: Trajectories for same 3-inch projectile and same velocity, in air and in vacuum.

17. Trajectory of German "75-mile gun." The projectile, getting through the denser lower air at the most advantageous angle, traverses the rarer air under conditions more like those in a vacuum. The air density at the summit is only 1/150 of that at the surface. The projectile thus secures a greater range than it would if fired at 45 degrees, as it would then have to spend more time in the denser levels.

Fig. 1

Fig. 2

Fig. 3

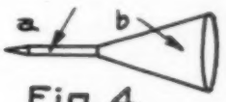


Fig. 4

Fig. 5

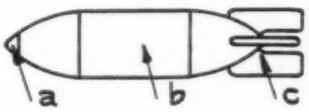


Fig. 6

Fig. 7

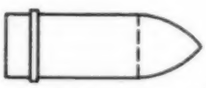


Fig. 8

Fig. 9

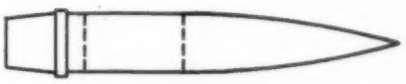


Fig. 10

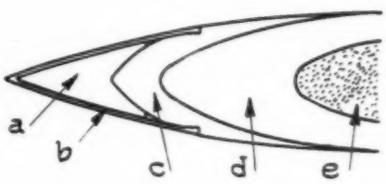


Fig. 11

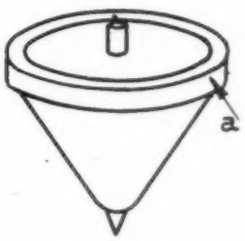


Fig. 12

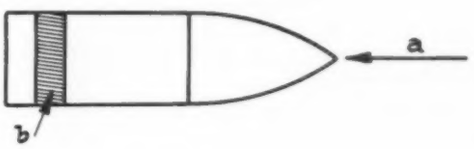


Fig. 13

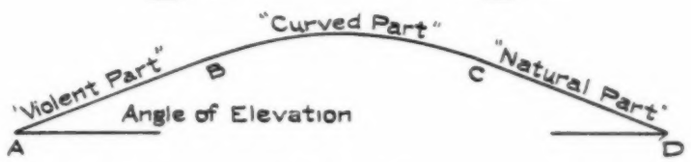


Fig. 14

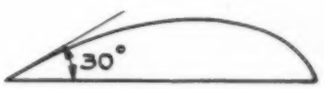


Fig. 15

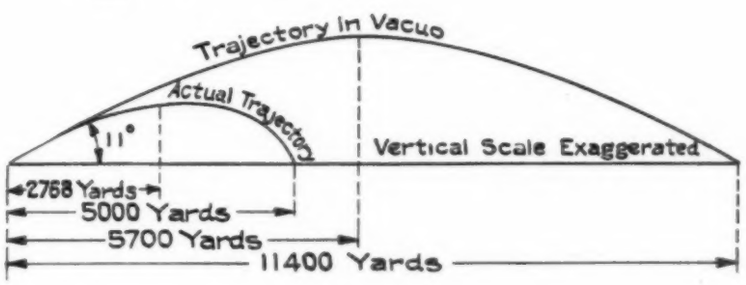


Fig. 16

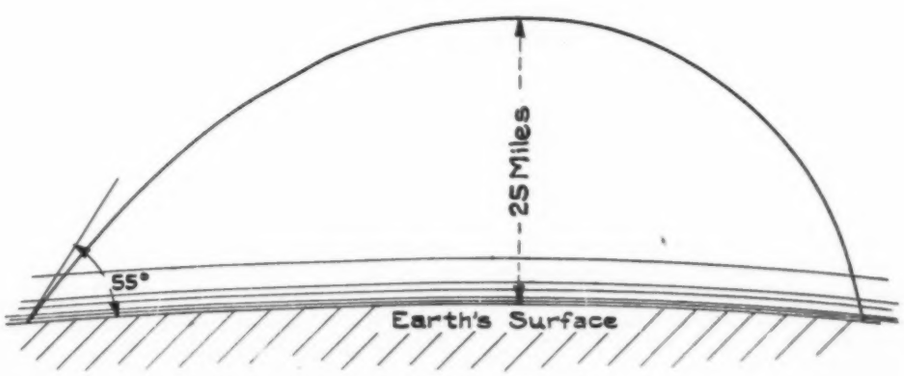


Fig. 17

the velocities, accelerations, forces, masses, etc., which are involved. These may be said to be the *differential equations of motion* for the projectile. Certain simplifying assumptions are always made. The more factors that are ignored the simpler becomes the theory, but the greater becomes the divergence between computations and observations. Simplifications in the equations become unjustifiable in proportion as matériel is improved and increased accuracy of fire becomes possible. The extreme simplification of ignoring air resistance was long ago admitted to be unsatisfactory for artillery fire, and is now made only for illustrative purposes or in elementary texts on mathematics and mechanics.

The comparative Figure 16 suggests some of the relations between what a certain 3-inch projectile actually does and what it would do if there were no air resistance. For the trajectory in air:

(a) The range is considerably shorter than that of the trajectory in vacuo.
(b) The maximum ordinate is less.
(c) The trajectory is not symmetrical.
(d) The angle of fall is greater than the angle of departure.
(e) The maximum ordinate is beyond the mid-point of the range.
(f) The velocity at any point in the descending branch is less than the velocity at the point of equal height in the ascending branch. In particular, the terminal velocity is less than the muzzle velocity.
(g) The trajectory is not a plane curve.

Previous to the World War the theory of ballistics was of approximately the same form in all countries. Which simplifications were to be regarded as satisfactory and which were not was a matter on which a practical agreement existed among most ballisticians. The mathematical methods used were those developed with great ingenuity by an Italian ballistician, Siacci, and further extended by Colonel Ingalls of our service, and were based chiefly on experiments conducted by the Krupps at Meppen in Germany, reduced by a Russian general, Mayevski, to equational form. Minor improvements and differences occurred in the various nations in their local methods, as was to be expected. In this country such improvements were due in large measure to Colonel Hamilton of the U. S. Coast Artillery.

Now, Siacci's whole point of view was to make use, to as great an extent as would be convenient, of the fact that the computations were intended for direct fire. He succeeded in what had been considered a hopeless task—that of constructing tables of small size well adapted to solving the whole ballistic problem for fire with guns which only in extreme cases were aimed as high as fifteen degrees above the horizontal. It was a considerable shock to such artillerymen as had been taught to accept Siacci's method without question when the newer models of powerful guns began to be used at higher elevations, and marked discrepancies began to appear between theory and observation. A spherical shell, such as was used in our Civil War, had a resistance nearly three times as great as the older ogival types (see Fig. 7, 8, 9) and about five times that of the modern boat-tailed, sharp-pointed type for the same caliber. (See Fig. 10.) It must be clear, then, that approximate methods which might be satisfactory with the earlier projectiles, would be disastrous with modern gun-fire.

By 1916, new methods were in use in France and in England to cover with accuracy these new types of trajectories. More or less complete ignorance of these methods persisted here until we were fairly into the war and until confidential pamphlets and reports treating of French and British methods began to be available in Washington. Although we were thus handicapped by a late start, it was but a short time before direct numerical interpretation of equations without two of Siacci's simplifying assumptions was part of the ballistic routine. One of these simplifications which was avoided made use of the fact that the curvature of the path was slight and a second that the density of the air could be regarded as having a mean constant value for the whole trajectory.

Despite the great serviceability of Siacci's method for the problem for which it was designed, it was obviously inexact at long ranges. For example, to cite but one feature, Siacci's form of the equations, as usually employed, yielded maximum ranges at 45 degrees elevation in all cases, just as is the fact for firing in a vacuum. The maximum range for the German long range gun was for about 55 degrees elevation (see Fig. 17), while that for a Springfield rifle is something under 30 degrees. (See Fig. 15.)

The matter of air density is one of importance. At eighteen and a half kilometers, the air is only one-tenth as dense as at the ground and a projectile goes through the air ten times as easily. This is at about eleven and a half miles up. While this altitude is entirely out of the question for human pilots in balloon ascents or in airplane flights, the projectile of the near future will exceed it. The German long range gun sent its projectile twenty-five miles up into the air, at which height the density of the air is only 1/150 of that at the surface; and this not with any attempt at an altitude record but merely to secure long ranges. Observations of temperature and pressure by means of self-recording instruments have been made even to heights like this.

The finest example of motion subject to complicated laws but solved in practical form by the use of "higher" mathematics is that of the heavenly bodies within our solar system. Here again we have as a first approximation, in the case of the moon, motion in a conic section about the earth as one focus. Except for illustrative purposes, the disturbing attraction of the sun cannot be ignored, and although resistance in the ordinary sense does not exist, the mathematical problem is essentially analogous to that of the projectile in air. One is scarcely surprised therefore to learn that the methods now used in ballistics were suggested by recently current methods in astronomical computations. They were first pushed through in this country by Prof. F. R. Moulton, Professor of Astronomy in the University of Chicago, while he was serving with the Ordnance Department during the recent war.

One of the larger undertakings at present under way by the Technical Staff is the construction of tables for exterior ballistics using these astronomical methods. The work is not simple and the tables will be necessarily very large. It is to be expected, however, that something like astronomical accuracy may be secured by their use provided that corresponding improvement in matériel is sustained. Such accuracy as that with which eclipses may be predicted is perhaps permanently beyond all possible attainments of artillery, but the comets need scarcely be regarded as more definite in their path than a well-behaved projectile. If a more or less permanent peace becomes probable, and target practice with major caliber artillery continues to increase in cost, the trajectory of a large projectile may become as rare but as dependable a phenomenon as a reappearance of Halley's Comet.

The Light Field Howitzer

By

H. C. ZIMMERMAN

THE following are extracts from the report of the Board of Officers appointed by Par. 142, Special Orders No. 289-O, War Department, 1918 (frequently referred to as the Westervelt or Caliber Board Program):

"The consensus of opinion of artillery officers is that the division artillery missions are best fulfilled by a light field gun and a light field howitzer having a range of at least 11,000 yards. There are many instances where the terrain offers such protection to infantry that the field gun cannot bring an effective fire. The howitzer has the great advantage that with a proper set of propelling charges and, therefore, a choice of trajectories for the same range, protected positions can be chosen for howitzers that guns could not use, and angles of fall on objectives obtained that the normal ammunition of guns would not give. The low muzzle velocity of howitzers admits of their almost continuous use in harassing fire and allows the use of a projectile double the weight of that of the field gun. Such a howitzer renders excellent service in wire cutting and is a useful projector of gas shells. To insure the mobility required of all divisional artillery the weight of the howitzer and carriage should not exceed that of the field gun and carriage or about 4,500 lbs. The German and Austrian armies were equipped with a howitzer of the light field type; this weapon had a caliber of 105 mm., firing a projectile weighing 34.54 lbs. at a maximum range of 10,500 yards (stream line shell). The weight of the howitzer limbered was 4,500 lbs."

The 105 mm. howitzer Model 1920 MII and the 105 mm. howitzer carriage, Model 1921, were designed to cover the above requirements. The carriage limber, Model 1920, is used with this matériel.

The general characteristics of this matériel as compared with 105 mm. howitzer carriage, Model of 1898-09 (German), are as follows:—

	105 mm. Matériel (United States)	105 mm. Matériel (German)
Total overall length of howitzer, inches	99.045	90.375
Weight of howitzer and breech mechanism, pounds	1,025	975
Muzzle velocity maximum, foot-seconds	1,500	1,400
Weight of shell, pounds	33	34.4
Zones of fire	5	9
Range, maximum, yards	12,000	9,186
Weight of carriage (only), pounds	1,943	2,070
Weight of limber without men, pounds	1,036	*2,070
Weight behind team, pounds	4,004	5,115
Weight of lunette, limbered, pounds	98	170
Width of track, inches	60	61
Diameter of wheels, inches	48	48
Tires	solid rubber	steel
Traverse, total, degrees	8	4
Elevation, total	0° to + 52° 30′	—9° to + 40°
Length of recoil, inches	45	51
Range, supercharge, yards	12,000	
Range, 1st zone, yards	2,750-3,900	
Range, 2nd zone, yards	4,300-6,200	
Range, 3rd zone, yards	5,650-8,100	
Range, 4th zone, yards	6,700-9,500	

Note: *26 rounds of ammunition in limber.

DESCRIPTION OF THE UNITED STATES MATÉRIEL:

Howitzer

The howitzer of the sliding block type is built up, consisting of the jacket, tube and several hoops. The tube and jacket are of alloy steel of the following minimum physical properties: elastic limit 80,000 lbs. per sq. inch; ultimate strength 105,000 lbs. per sq. inch; elongation 18 per cent and contraction of area 30 per cent. The maximum pressure in the bore is 26,000 lbs. per sq. inch.

Recoil Mechanism

A St. Chamond hydro-pneumatic type recoil mechanism is used to check the movement of the howitzer to the rear and to return it into battery after firing. The mechanism forces oil through a spring-controlled valve to check the recoil and by means of compressed nitrogen returns the piece into battery. The oil and nitrogen are separated by a movable diaphragm (floating piston).

The general characteristics are:

Weight, complete, pounds	377
Initial nitrogen pressure, lbs. per sq. inch	650
Maximum nitrogen pressure, lbs. per sq. inch	840
Maximum oil pressure, lbs. per sq. inch	5,200
Recoil cylinder, test pressure, lbs. per sq. inch	9,000
Resistance to recoil at 0° elevation, lbs.	15,230
Piston rod test pull, pounds	34,000
Maximum length of recoil, inches	45
Time of counter recoil, seconds	3

The body of the mechanism is a steel forging pivoted near the rear end on trunnions which rest in the trunnion bearings of the carriage. The trunnions are steel castings which are secured to the body of the mechanism by keys and screws. The trunnions are placed at the rear end of the body of the mechanism in order that the howitzer may clear the ground when fired at the maximum elevation permitted by the carriage.

The recoil mechanism is made as light as possible. The regulator is made of aluminum alloy, as mentioned in the Rock Island Notes of ARMY ORDNANCE, November-December, 1921.

The recoil and recuperator cylinders in the mechanism body are polished to a mirror finish. A scratch in one of these cylinders is sufficient cause to reject the piece. A cover of armor plate protects the front of the recoil mechanism from rifle fire.

The action of the powder gases on the howitzer causes it to recoil. The recoil piston rod is fastened to the howitzer lug so that it moves to the rear carrying the piston with it. The movement of the piston produces a pressure on the oil in the recoil cylinder. As this pressure increases it overcomes the resistance of the throttling valve spring, opening the throttling valve and permitting the oil to flow into the recuperator cylinder. In flowing through the valve, a throttling resistance is produced.

The oil entering the recuperator cylinder forces the movable diaphragm forward, compressing the nitrogen. The frictional resistances of the piston rod through the stuffing box of the recoil cylinder and of the movable diaphragm in its cylinder add to the throttling resistance of the oil and the resistance to compression of the nitrogen, producing the total resistance of the recoil mechanism on the howitzer.

At the end of recoil, the compressed nitrogen exerts a force on the movable diaphragm forcing the oil ahead of the piston, back into the recoil cylinder. This oil pushing against the recoil piston pulls the howitzer into battery. The oil is throttled by the buffer valve as it returns to the recoil cylinder. The last few inches of counter recoil are controlled by the buffer rod entering its chamber; this decreases the velocity and allows the howitzer to return to battery without shock.

Carriage

The carriage has a box trail with axle traverse, rubber-tired wheels, independent line of sight and shields.

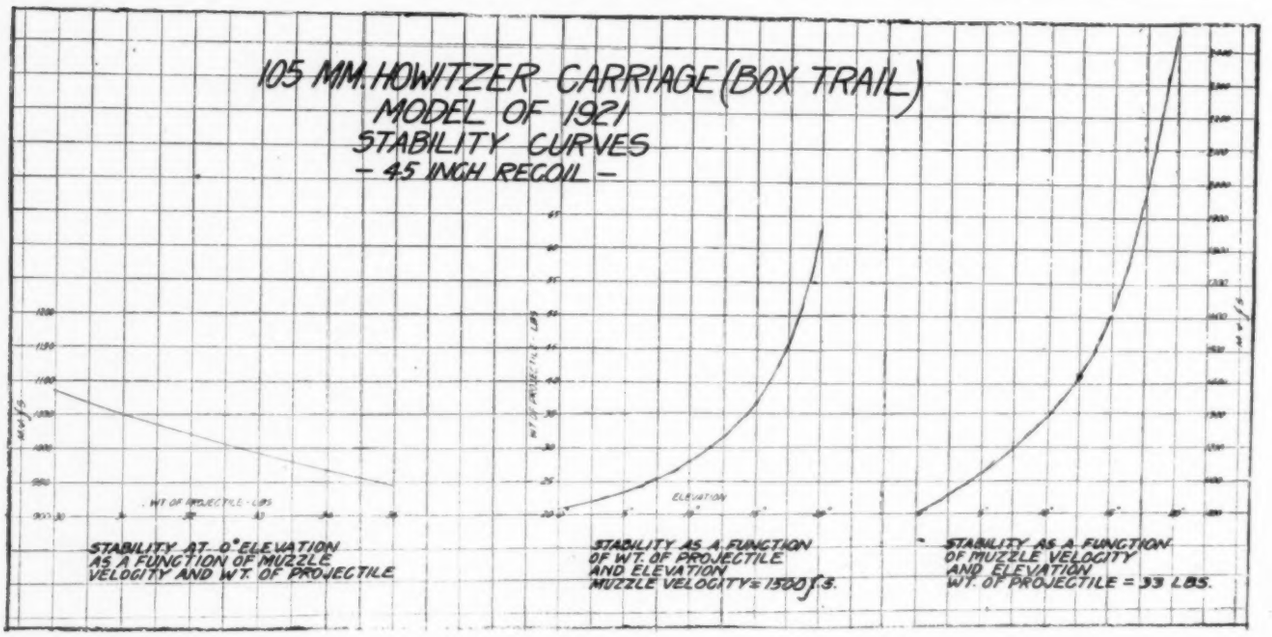

105 MM. HOWITZER CARRIAGE (BOX TRAIL)
MODEL OF 1921
STABILITY CURVES
- 45 INCH RECOIL -
STABILITY AT 0° ELEVATION AS A FUNCTION OF MUZZLE VELOCITY AND WT. OF PROJECTILE
STABILITY AS A FUNCTION OF WT. OF PROJECTILE AND ELEVATION MUZZLE VELOCITY = 1500 f/s.
STABILITY AS A FUNCTION OF MUZZLE VELOCITY AND ELEVATION WT. OF PROJECTILE = 33 LBS.

Fig. 1

The principal parts of the carriage are the recoil mechanism, which has been described, and the elevating mechanism, angle of site mechanism, equilibrator, axle and wheels, traversing mechanism, trail, road brake, shield and sight and range drum.

The elevating shaft is carried in housings on the under side of the recoil mechanism body. There are two pinions on this shaft which mesh with the teeth on the rockers. The rockers are segments of spur gears whose hubs form bearings for the cradle trunnions. A worm wheel is carried on the right end of the elevating shaft; the handwheel shaft is an extension of the shaft of the worm. A clockwise rotation of the handwheel elevates the piece. One turn elevates 8 mils.

The angle of site mechanism is similar to the elevating mechanism. The angle of site shaft is supported on brackets that are bolted to the trail connections. The pinions on this shaft engage the teeth of the rocker. The worm and handwheel are on the left side of the carriage.

At maximum depression of both angle of site and elevating mechanisms, the howitzer is horizontal.

The trunnions of the recoil mechanism are at the rear end of the mechanism body and it is necessary to provide an equilibrator to relieve the elevating mechanism. This consists of telescoping cylinders with a helical spring assembled within. The upper cylinder is supported in a bracket on the lower side of the recoil mechanism body. The other cylinder is supported in brackets on the trail. The force stored in the spring column balances the preponderance of the tipping parts at all elevations.

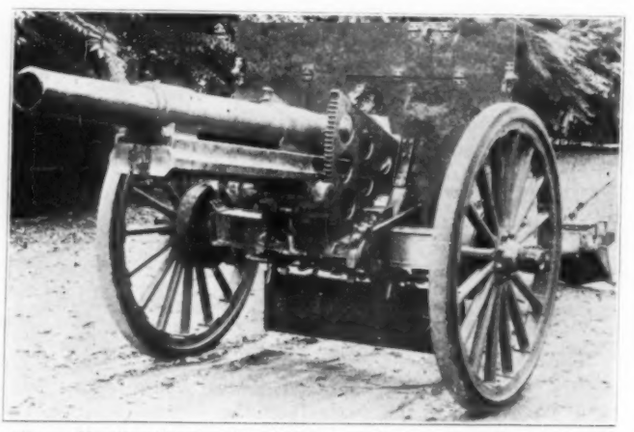
The axle is forged with axle arms integral with the body. The axle arms are of standard dimensions and the body is of I-beam section with the web vertical (in battery) and curved to an arc centering in the spade. The traversing rack is bolted to the rear of the web of the axle and stops screwed to the under surface of the flange limit traverse.

The wheels are a modified Archibald pattern with solid rubber tires. The weight of one wheel with the brake drum attached is 246.5 lbs. The wheel fastening is a bronze yoke fitting in the outer end of the axle arm and is accessible when the hub cap is removed.

The carriage is traversed by sliding the front of the trail laterally on the axle, describing an arc about the spade as a pivot. The sliding motion is accomplished by the traversing mechanism. The traversing handwheel is located on the left side of the trail. Turning the handwheel clockwise (as viewed from the left side of the carriage), forces the trail along the axle to the left. One turn of the handwheel traverses two mils.

The trail sides are parallel and built of nickel steel plates, formed into a box section. The forged steel trail connections at the forward ends of the trail are slotted to embrace the axle. The trail connections are fitted with special roller bearings on top of the axle, to reduce friction during traverse, and have bronze bearing plates underneath. Near the trail connection the top carriage is riveted to support the trunnion bearings. The sides of the trail are connected at the front end by the traversing bracket and at their rear ends by the spade and tool box.

The trail is provided with the large size lunette for pos-



105 mm. Howitzer Carriage, Model 1921E. Left front view with cradle lock engaged.

sible use with a tractor and the usual cannoneer's seats, trail handles, folding handspike, sponge and rammer fastenings, tool box with a lock and roller wheel guards.

The hand brakes on the wheels are controlled by means of a brake line extending to the rear of the trail and

operated through small cables by a cannoneer seated on the carriage limber.

A cradle lock is provided joining the trail connections and the elevating gear housing on the body of the recoil mechanism. Its use relieves the maneuvering mechanisms from road shock in transport.

Armor plate shields for the protection of the cannoneers from enemy fire are a little forward of the trunnions. The top of the shield is hinged and is arranged to fold over the head of the panoramic sight, thus permitting the use of aiming points throughout 360 degrees of azimuth.

Heat Treatment of Parts

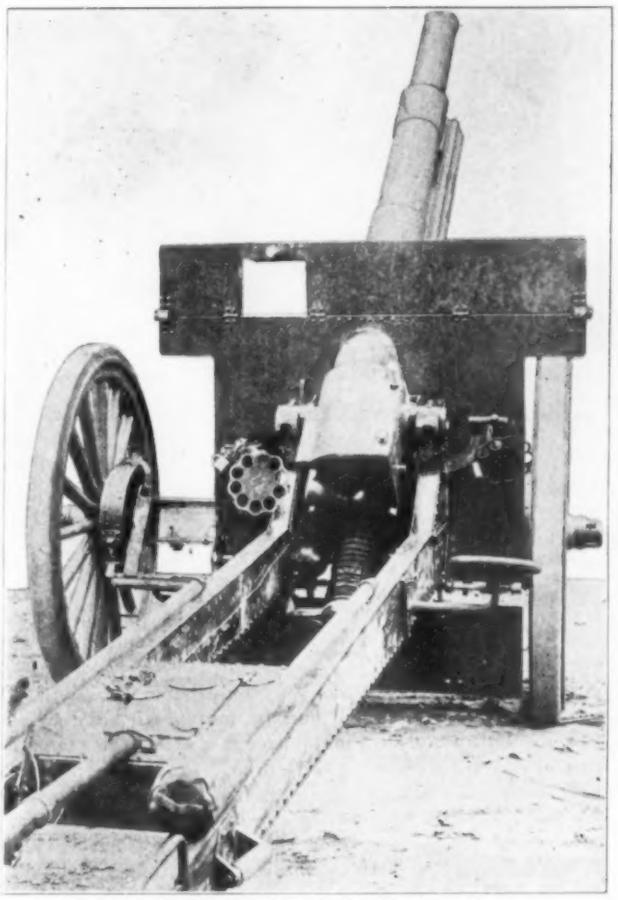
Some of the more important details of the carriage have had special heat treatments prescribed to increase their ability to withstand the shocks imposed on them in firing and on the road. The shafts for elevating and angle of site are of forged steel B(F) scleroscope hardness 50 to 60. The equilibrator trunnion is of the same material as the shafts but is specified Brinell 225 to 250. The equilibrator spring is of silicon manganese spring steel, annealed, and the computed fibre stress is 140,000 lbs. per square inch.

The trails are nickel steel plates .125 thick, with an elastic limit of 63,000 lbs. per sq. inch. Nickel steel (3½ per cent nickel) rivets were used in the trail.

The spade edge is steel (S. A. E. 6150) heat treatment T or V, Brinell 425 to 475.

The axle is of forged steel B(F) (about S. A. E. 2340) and the test coupon showed an elastic limit of 68,900 lbs. per sq. inch and 100,625 lbs. per sq. inch tensile strength, with a Brinell of 207. It was heat treated before machining.

Preliminary firings at Aberdeen have proven the carriage to be satisfactory; 126 rounds have been fired. The pressure of the nitrogen in the recoil cylinder was increased from 650 lbs. per sq. inch to 725 lbs. per sq. inch during the cold weather in December. Slow motion pictures were taken of several rounds to get a record of the action of the piece. In the rapid fire test ten rounds were fired in 54.56 seconds which, considering the shell is put in and rammed before the cartridge case, is very good time. Several rounds were fired with overcharges up to 115 per cent as a safety test. Also the carriage has been placed against a concrete base and fired to test the trail.



105 mm Howitzer Carriage, Model 1921. Rear View.

The Electric Gun Shrinking Furnace

By

J. L. HUGHES

Member A. O. A.

UP to January 15, 1920, all tubes, hoops, jackets, recoil bands, etc., assembled at Watervliet Arsenal were heated in an oil-fired furnace to the required temperature. The temperature to which the various forgings are heated is the lowest temperature which will provide sufficient expansion to take care of the shrinkage allowances on the male piece and provide sufficient clearance for the ready assembly of the heated forging. The temperature to which the forgings are heated is seldom in excess of 800 degrees F. and must always be less by a safe margin than the last annealing temperature used in manufacturing the forging which is under consideration so as not to affect its physical properties. The last annealing temperature is usually between 1000 degrees and 1200 degrees F. so that 800 degrees F. is considered a safe temperature to heat all gun forgings to.

In heating a gun forging to secure the required expansion it is absolutely necessary that it be uniformly heated throughout and not too rapidly. In order to accomplish this result, it is imperative to heat the forging without having the flame come in contact with it. It is also desirable to have control of the temperature at different points in the furnace so as not to overheat or raise the temperature of the thinner sections of the forging too high while heating the thicker sections of the forging to the desired temperature.

The oil-fired furnace which used crude fuel oil consisted of a boiler plate cylinder, lagged on the exterior with an asbestos covering to provide heat insulation. Inside of this cylinder there was a wall of fire brick. Next came the fuel and air pipes of the furnace proper, the fuel and the air at about forty pounds pressure per square inch being fed

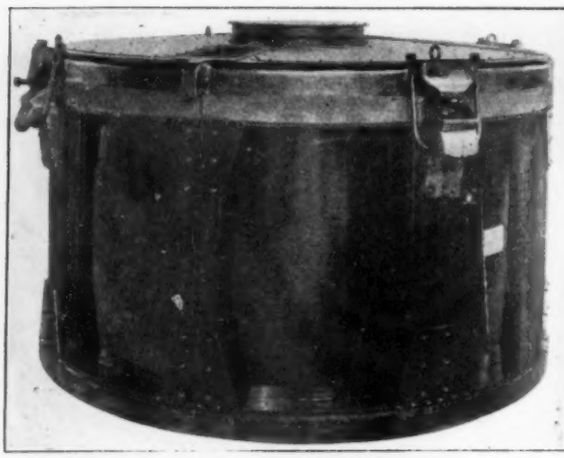


Fig. 1. Shrinking Furnace.
One Section with Cover.

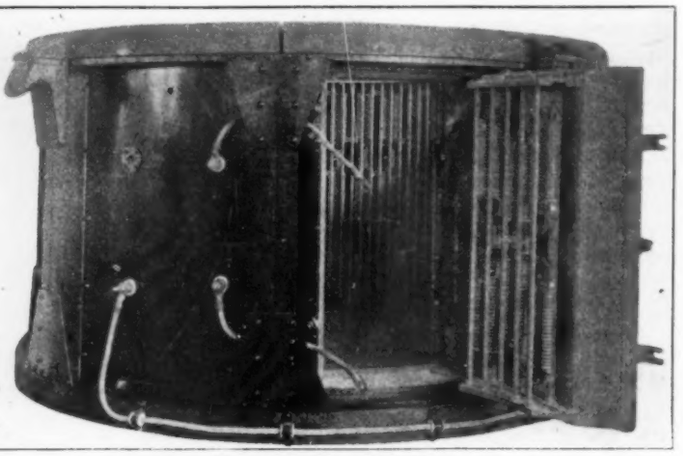


Fig. 2. Shrinking Furnace.
One Section with Door Opened.

through the oil burners. The fuel feed pipes consisted of four vertical pipes running the entire length of the furnace. Auxiliary feed pipes consisting of cylindrical rings were connected to the main feed pipes every five feet. Four oil burners were attached to each cylindrical feed pipe, the burners on the alternate feed pipes being located one-half way between the burners on the feed pipes adjacent to it so as to stagger the burners and not concentrate the heat in a vertical line. Valves controlling the flow of fuel and air were brought to the outside of the furnace.

The oil-fired furnace was very unsatisfactory in that it was necessary to light the burners individually and to adjust the air and oil on each burner if a change in temperature inside the furnace was desired. It often happened that during the heating of a large forging (which in some instances requires as much as twenty-four hours) the burners would become dirty and refuse to burn longer so that it was necessary to have men in constant attendance, climbing around the outside of the furnace in order to keep the burners adjusted and burning properly.

A cylindrical baffle of $\frac{3}{8}$-inch boiler plate was provided for the inside of the entire furnace so that the flame from the burners would play on the baffle plate, thereby preventing it from coming in contact with the forging which was being heated. The flame on the baffle plate was directed at an angle so as not to heat it red hot and burn through.

All forgings were supported from the bottom of the furnace. No forgings were ever suspended from the top of the furnace, as the construction was such that sufficient strength could not be readily provided to accomplish this desirable feature.

On January 15th the oil furnace collapsed and it was necessary to repair it immediately or to install the new electric furnace. The latter course was decided upon and since it was expedient to complete the installation at an early date, in order to avoid stoppage of all work on the manufacture of 14-inch and 16-inch guns, three-shift operation was authorized and the new electric furnace was completely installed and ready for operation in April, 1920.

This furnace is composed of thirteen sections, each section being approximately 6′ 8″ inside diameter, 10′ 5″ outside diameter and 5′ 6″ high; each section requires sixty-eight kilowatts at normal voltage, giving the entire furnace a rating of eight hundred and eighty-four kilowatts.

The actual depth of the furnace is 72′ (each section being a complete mechanical and electrical unit) and operates on a 3-phase, 220-volt, 40-cycle circuit at unit power factor.

Power is supplied to the furnace from an 11,000-volt, 3-phase 40-cycle transmission line connected to three step-down, oil-cooled, oil-insulated, outdoor type transformers of 400 k. v. a. capacity each. The transformers have an 11,000 volt primary winding and a 230/460 volt secondary winding, being connected in series multiple on the low voltage side, the conection being 3-phase delta.

The secondary winding of the transformer consists of four 115-volt coils, the coils being connected in groups of two inside of the transformer to form two 230-volt windings, four cables are brought through the transformer permitting a series connection giving a voltage of 460 volts or a series multiple connection giving a voltage of 230 volts, the latter voltage being the one used in operating the furnace.

Power is conveyed from the transformer busbars to the switchboard through three one million circular mil, extra flexible, varnished cambric cables, there being located on the switchboard three single pole air brake circuit breakers. The switchboard is provided with current and voltage transformers for operating a graphic meter installed on the board. There are located on the switchboard eighteen automatic contactor switches, one contactor switch being required for each section of the furnace. The extra five contactor switches are used for operating a smaller electric furnace similar to the one described but which consists of only five sections, being used for shrinking of smaller cannon.

A control room is provided having one panel for each section of the furnace, each section having a triple pole contactor switch electrically operated protected by fuses. On each panel there are mounted two ammeters; ammeters being provided for two of the three phase lines. Current transformers are mounted on the rear of the main switchboard. On each control panel there are also mounted two indicating watt-meters, indicating the load on each section of the furnace. Toggle switches mounted on a desk-like panel placed directly in front of the recording pyrometers are so located that the operator does not have to move in order to operate the contactor switches placed on the main switchboard. With this arrangement he is able to cut off or turn on the power on any section of the furnace as required. Each section of the furnace is provided with two adjustable thermo-couples located on opposite sides of the section, one being located near the bottom of the section and one near the top.

The sections are arranged so that the thermo-couples are staggered throughout the entire length of the furnace. The thermo-couples are adjusted so that they actually come in

contact with the metal of the gun or forging which is being heated. The temperature readings of the twenty-six thermo-couples are recorded in thirteen minutes automatically by a Leeds & Northrup recorder. There are two Leeds & Northrup recorders, each one recording the temperature of thirteen thermo-couples.

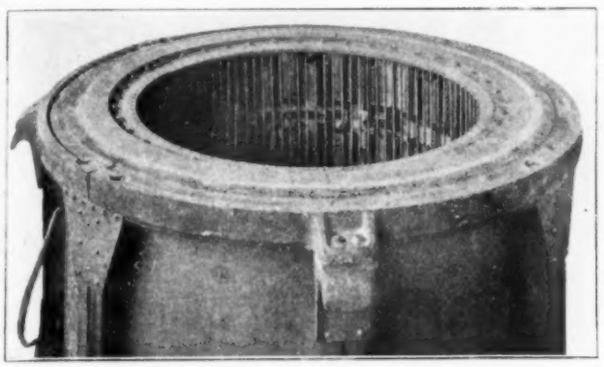


Fig. 3. Top of Gun Shrinking Furnace.

Each section of the furnace being a separate mechanical and electrical unit makes it possible to remove any section (simply by lifting it off with a crane) and use it as a separate furnace at any convenient location.

A structural steel and iron inner and outer frame is provided as a part of each section, being so constructed that the outer frame carries the entire weight of the other sections of the furnace assembled on top of it. The outer frame is insulated from the inside of the furnace by a wall of heat insulating brick so as to eliminate any possibility of the outer frame being heated to a temperature which might distort it. The inside of the furnace is built up of cast iron, planished iron, and calorized steel parts, none of which are attacked by a temperature of 1000° F. or less. 1000° F. is the temperature at which the furnace is rated. The inner structure is not connected to the outer frame by any through bolts or through metallic parts and it is therefore free to expand in diameter or length without disturbing the outer furnace frame.

The heating element or resistance unit consists of a calorite ribbon approximately 1/3″ wide made up into units of about 20′ lengths, each unit being complete with its insulator and cast iron supporting plate.

Figure 2 shows the heating units assembled and the open door which is usually provided on the lower section of the furnace. This illustration also shows the calorized guard rods which are assembled on a flange in front of the heating units which are provided to prevent the possibility of injury when lowering a gun or forging into the furnace. The calorite ribbon with which the heating unit is wound is a nickel alloy consisting of approximately seventy per cent nickel; twenty per cent chromium and ten per cent iron and can be run at a temperature of 1800° F. in air without apparent depreciation. The insulators themselves are made from a special alundum compound having great mechanical strength and electrical resistance with the ability to retain both of these properties at a temperature considerably above the operating temperature of the furnace. The insulators with the heating unit have been repeatedly heated to a temperature of 1300° C. and quenched in oil or water without crazing. This latter feature is of the utmost importance as in a shrink pit an accident is liable to happen which might flood the bottom of the furnace with water.

The top section of the furnace is provided with a split cover, the halves of which move aside to allow the forging to enter or emerge from the furnace. This feature permits the suspension of a gun or forging from a fixture provided with a suspending shaft extending through the center of the cover and supported on I-beam girders on the outside of the furnace. These girders are on rollers and can be moved out of the way when not required. The heating units being located on the inside of the furnace, the heat will be transferred from them to the charge largely by direct radiation. The heating units operate at a comparatively low temperature (only 100° to 200° above the temperature of the charge) as compared to that of the baffle oil type furnace in which the charge must be first heated through the walls of the baffle. The heating unit is located far enough away from the walls of the furnace so that it can readily dissipate its heat and, being of such small cross-section, heats very rapidly. The fact that the furnace is made in sections permits it to be readily assembled or disassembled to any desired height by simply adding or removing sections.

Sets of heating units are connected to each phase of a 3-phase circuit so that two or more sections of the heating unit constitute a polyphase unit which gives a balanced load on the power circuit. One of the outstanding features of the control is that it permits controlling from the heat unit, which is a body of small mass, and maintaining there just enough temperature to supply the radiation losses of the furnace and gives the required temperature to the charge. This may be called an indirect control and has very marked advantages. One advantage is the arrangement of the contacts whereby the resistor can never reach a temperature sufficient to cause damage to itself, which affords protection against burn-outs in case of abnormal voltage; and, which is equally important, no part of the charge can become overheated for the reason that all heat which enters a body must pass through its surface and, as the surface temperature cannot exceed the setting of the instrument, it follows that no part of the charge can be overheated.

The fact that accurate control of the temperature is possible makes this type of furnace very efficient, as it is possible to graduate the temperature from end to end as required for the different thickness of the forging. The absence of noise, heat, smoke and products of combustion, with the ability to locate the furnace in any part of the shop, are great advantages which can be obtained when

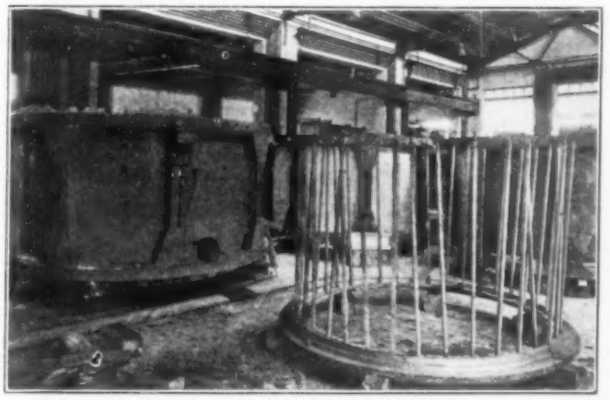


Fig. 4. Assembly of Gun Shrinking Furnace.

using this equipment. The necessity of the transportation and storing of fuel oil is also eliminated. It is found that at present the electric furnace can be operated approximately fifteen per cent cheaper than the oil furnace, this percentage not taking into consideration the maintenance and upkeep of oil storage facilities.

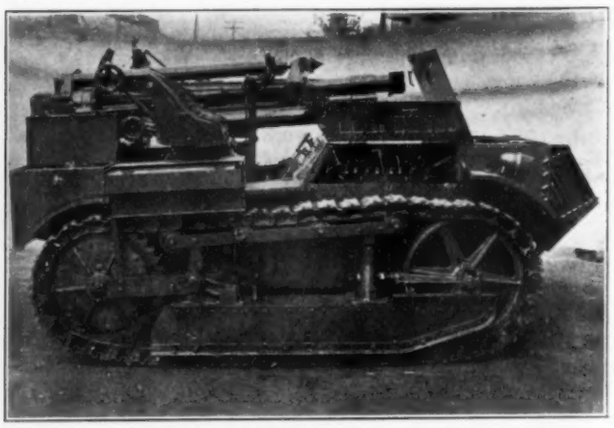
Cooling Cadillac 8-Cylinder Motors

By

LEVIN H. CAMPBELL, Jr.

Member A. O. A.

THE Mark VII Motor Carriage for 75-mm. Gun is propelled by a Standard Cadillac 8-Cylinder Motor. It will be recalled that this is the same motor as used in the 2½-ton Tractor, Model of 1918. It has been found impossible to satisfactorily cool the engine under such ex-



Mark VII. Motor Carriage for 75-mm. Gun

tremely heavy duty, both as regards circulating water and crank case oil, in both of the above vehicles.

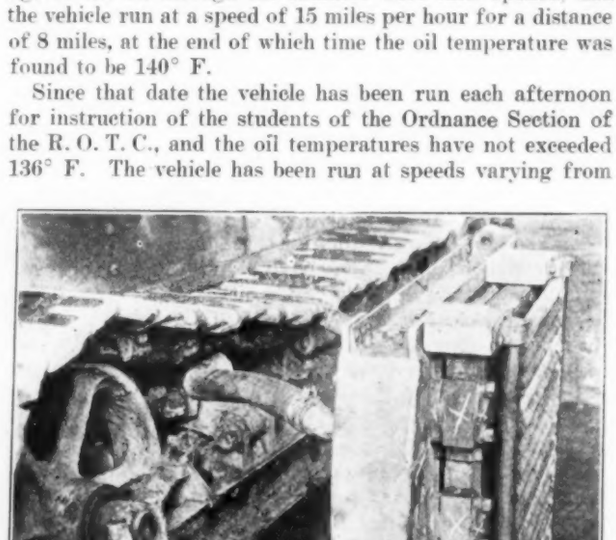
It has been a common experience for the water to constantly boil at average climatic temperatures, resulting in the frequent refilling of the radiator while on the road. The temperatures of the crank case oil have run excessively high, often as great as from 180° to 200° F. It is considered by Automotive Engineers that an engine works most satisfactorily with the cooling water at the top of the radiator at a temperature of approximately 180° F. and at the bottom at approximately 160° F. It is also considered that the temperature of the oil in the crank case should never exceed 160° F. in order that the oil may retain its viscosity and lubricating properties. Above that temperature the wear of the cylinder walls, piston rings and bearings is very rapid. In fact, in the tests of the Mark VII Motor Carriage it has been found necessary to replace the motor after each period of test of 500 miles.

With a view to overcoming the difficulties mentioned above in the least expensive way and without serious modification, the capacity of the Standard 2½-ton Modine radiator was increased 50 per cent by the addition of extra sections of radiator cores. The method of adding the additional sections is quite clearly shown in the accompanying photograph. The space blocks marked with the white "X" are drilled to permit the circulation of water from the headers to the sections. After the modifications to the radiator the vehicle was run a distance of 42 miles at an average speed of 10 miles per hour on a day with an air temperature 85° F. Upon the completion of the run it was found that but a quart of water had been lost through evaporation. Encouraged by this success, the cooling of the crank case oil was next undertaken.

An oil radiator, as shown in the illustration, was made in the Plumbing Shop at the Aberdeen Proving Ground and was connected with shut-off and by-pass valves in the lines to the pump orifices found in the Cadillac motor. This radiator consists essentially of two tubular headers connected by a series of vertical risers with baffles appropriately placed in the headers. These baffles are for the purpose of insuring that the radiator is kept full of oil, and that the oil circulates through all of the risers so that the maximum cooling effect may be obtained. The radiator is mounted in front of the water radiator as shown in the illustration.

The radiator was installed last winter and the vehicle was held for test in warm weather. On June 17th, a day on which the sun was shining and the air temperature was 88° F., the vehicle was run for a period of two hours at speeds varying from 5 to 15 miles per hour a distance of approximately 15 miles. The valves which control the oil radiator were closed, that is to say the oil was pumped through the by-pass directly back into the bearings and did not pass through the radiator. The temperature of the oil was 74° F. at the beginning of the run. At various intervals of time the temperature was taken and it was found to be steadily mounting. At the conclusion of the two hour run the reading was 172° F. The valves which control the passage of the oil through the radiator were then opened, and the vehicle run at a speed of 15 miles per hour for a distance of 8 miles, at the end of which time the oil temperature was found to be 140° F.

Since that date the vehicle has been run each afternoon for instruction of the students of the Ordnance Section of the R. O. T. C., and the oil temperatures have not exceeded 136° F. The vehicle has been run at speeds varying from



75-mm. Gun Motor Carriage, Mark VII Modified Water Radiator. Radiation Increased 50%

6 to 15 miles per hour for intervals of about 2 hours. The temperature of the cooling water has remained not in excess of 195° F., after runs at speeds of 15 miles per hour. At the lesser speeds the temperature has been found to be on the average 185° F.

Salvaging Rifle and Machine-Gun Barrels

By

CHAS. F. ARMSTRONG

Member A. O. A.

AT the outbreak of the recent World War all the nations in Europe found themselves confronted with almost the identical conditions that we found when we entered the war; that is, a shortage of the latest pattern or type of small arms and machine guns. The English, to correct their shortage immediately, let contracts in the United States for huge quantities of small arms. The French and Russians immediately followed, and then each nation in turn supplemented these contracts with contracts for machine guns.

At the time the war commenced England was about to adopt a new small arm of .27 caliber. This was abandoned, and the Lee rifle, known as the Lee-Enfield, and afterwards commonly known as the "Enfield," was made by the Remington Arms Company and the Remington Eddystone Works, for the British .303 cartridge.

This last rifle, modified and changed to take the U. S. cartridge caliber .30, Model 1906, was adopted by the United States to supplement the manufacture of of the U. S. rifle, caliber .30, Model 1903, commonly known as the "Springfield," as the tools to make it needed very little changing.

The English adopted the Vickers-Maxim gun, for their machine gun, and these were made also in the United States by the Colt Company at Hartford, Conn.

The old Colt machine gun was modified and manufactured for the Russian Government, to take the Russian cartridge, by the Marlin Rockwell Company at New Haven.

Thousands of Russian rifles were made by both the Remington Company and the Westinghouse Company.

In the meantime the Italians found themselves with enormous quantities of the 11-mm. guns, and a small number of the 6½ mm., this latter rifle being the most recently adopted by them, and the problem on their part to supply sufficient small arms became very difficult.

So they experimented in various ways, in the hope of finding some way of utilizing the 11-mm rifle and thereby expedite the manufacture of the 6½ mm.

Mr. Salerno, an Italian, invented what is now known as the Salerno Process of retubing gun barrels, and I had the opportunity of investigating the Salerno Process, as being carried out by the St. Etienne arsenal, in France.

The Salerno Process consists of fitting an inner tube into a barrel, which is either too large, or has been worn out; and in considering this process, it may be well to divide the description of the operation into four parts:

(1) Preparing of the barrels,
(2) Preparing of the tubes,
(3) Assembling the tube and barrel,
(4) Finishing the arm.

Preparing the Barrel

The old barrel is bored out to a diameter of 11.57 mm. with a tolerance of 0.03 of a millimeter. The operation is done on a Pratt & Whitney drilling machine, the barrel being held firm and fed without revolving at the rate of 12 mm. in a minute. A four-fluted reamer, revolving at a speed of 900 to 1,000 revolutions a minute, increases the size of the bore. Soda water with a high percentage of oil is forced through the barrel from the opposite side to the reamer, pushing the chips away. The reamer has an end to guide it about 20 mm. long. The barrel-hole is not polished as it seems to be better to leave it rough to improve the adherence of the tube that enters it. When the Italians transformed the 11 mm. barrel to make it fit the 6½ mm. ammunition they did not even ream out the lands of the rifling.

Next a false chamber is made with four reamers of increasing size. There is again no polishing. This last, while an easy operation, requires considerable accuracy. The tolerance is limited to 0.03 of a mm. The barrel is now ready. (Fig. 1.)

Preparing the Tubes

Round bars of rough stock steel 21 mm. in diameter are used. First the bars are cut in lengths of 500 mm. and the ends squared off and prepared for the drilling machine. Next a hole 5.8 mm. is drilled on a Pratt & Whitney drilling machine, the drill revolving at the rate of 2,200 r. p m., with a feed of 24 mm. per minute. (Fig. 2.)

The hole is reamed out to 6 mm. Two reamers are used, first a four-fluted reamer, and next a flat reamer. Next the ends are faced off, and the hole is countersunk. Then the tubes are very carefully straightened, placed in a lathe, turned to 19 mm. in diameter outside. One end is left rough to be gripped in the drawing machine. Then the hole is reamed out to 9.6 mm. for a length of 360 mm. The tubes are then placed in a furnace and the large bored end hammer-drawn on a forging machine at the rate of about 40 bars per hour. The metal is heated to a cherry red.

The purpose of this operation is to make one end smaller than the smallest die, so that it will freely pass through to be caught by the drawing pincers of the drawing machine. The tubes are then heated in a special furnace divided into 9 parts (Fig. 3), being passed from one part to the next for re-heating after each drawing, making nine times that it is drawn through the reducing dies, each time brought to a cherry red, drawn through a die, placed into the next compartment of the heating furnace, reheated, and drawn through a next size smaller die, and so on, until the drawing is complete.

The tubes are not drawn through the entire length, but the machine is stopped each time at the proper spot so as to produce a varying profile outline. This is necessitated by the fact that the barrel being prepared has been reamed

to varying diameters and the exterior of the tubes must be made to conform approximately to this. (Fig. 4.)

The diameters of the dies are as follows: 18.3, 17.5, 16.7, 15.65, 14.75, 13.7, 12.75, 12.30, and 11.75 mm. The machine moves 910 mm. a minute; this might be increased for the smaller dimensions. Tubes are then annealed and cooled in cinders.

Next cut off part A, which was left simply for gripping purposes. This is done in a lathe in the ordinary way. The straightening of the tube is done in the ordinary way of straightening a rifle barrel, but more or less roughly, and it is straightened on the outside with an ordinary flat rule. Then the tubes are given an acid treatment, to clean them of all scale, etc. This acid treatment consists of sulphuric acid 20 per cent and water 80 per cent. The temperature of the bath 60°, and they are washed off afterwards in clean water.

Next the tube is reamed out on a Pratt & Whitney drilling machine, the speed of the reamers being 1,000 r. p. m. The first reamer, a three-fluted one with a diameter of 5.8 mm. is pushed through the barrel. The second, another three-fluted reamer, 6.2 mm. in diameter, pulled through in the opposite direction, followed by a third one 6.3 mm. in diameter Then the tube is polished with a flat reamer 6.4 mm. in diameter. Tolerance 0.10 mm. The tube is again straightened. Then the large end of the tube turned to its correct shape on a lathe. (Fig. 5.)

This operation requires a certain amount of accuracy and the entire tube is polished on a leather belt covered with emery.

Assembling the Tube and the Barrel

Due to the tolerance it is necessary to make some selection of tubes and barrels in order to match them, the condition being that the tubes must be just tight enough to force in by hand. They are driven home by knocking the larger end of the tube on an anvil set on the floor. The barrels with the tubes are then put in the lathe, and the small end of the tube is cut off 10 mm. beyond the end of the barrel. Next the tube is expanded, and this is done on a drawing machine of ordinary type. A rod with an olive-shaped end is drawn through the tube, which is held firmly at both ends so that it can not be elongated.

The diameter of the first tool varies, depending on the size of the bore, before the first operation. The first tool is drawn through and then a series of tools, increasing 0.03 mm. in diameter.

If one tool goes through fairly easily, it has been found best to omit the next size, and take a size larger. A dynamometer placed on the machine gives the information concerning the amount of power used in drawing the tool. The average power required is about 1,000 Kgr. at the part near the chamber and 700 to 800 Kgr. at the other part.

Testing for adherence. It was found that the best way to test for adherence was to hang the barrel on a string and tap it lightly to make it ring. If it did not ring clear, the adherence was not complete, and another expanding tube was drawn through it. It was found that care must be taken with the Hotchkiss barrel to pick out a standard, as, owing to numerous implements attached to the barrel the sound is not quite as clear as it would be on a plain barrel.

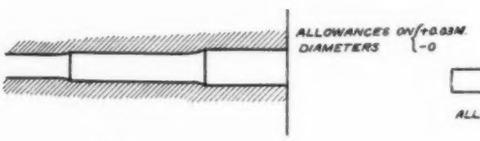


FIG. 1

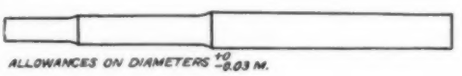


FIG. 5

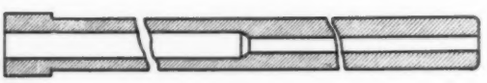
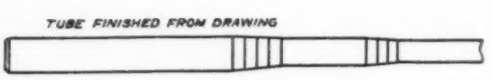


FIG. 2

FIG. 3



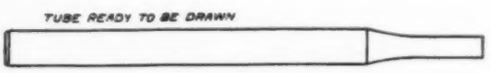


FIG. 4

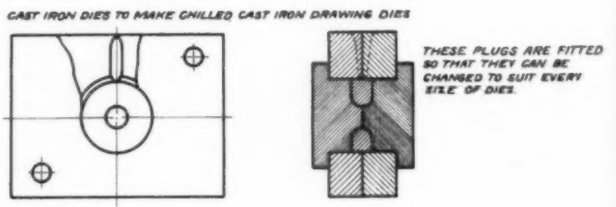

CAST IRON DIES TO MAKE CHILLED CAST IRON DRAWING DIES
THESE PLUGS ARE FITTED SO THAT THEY CAN BE CHANGED TO SUIT EVERY SIZE OF DIES.

FIG. 8

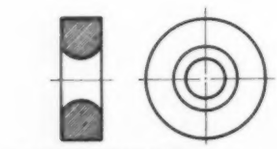


FIG. 7

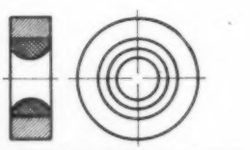


FIG. 6

FIG. 9

Percentages of loss. The proportion of scrap barrels during the process is as follows:

In the preparation of the barrels 1 per cent.
In the preparation of the tubes 15 to 20 per cent. (Much of this loss being due to the tube becoming chilled in drawing, and breaking.)
Fitting the tube to the barrel 2 per cent.

It was noted that 20 per cent of scrap tubes were not entirely lost as they were drawn and used in the making of drills for the Pratt & Whitney drilling machine.

Finishing the Arm

After the expanding process just described, the barrels are reamed and rifled and chambered exactly like an ordinary barrel. That completes the process.

A rough estimate of the cost gives a price of 1 Fr. 75 for labor per barrel for an output of 100 barrels a day. To this must be added the price of the steel and running expenses. The original cost of a new Hotchkiss barrel is roughly 250 francs Consequently this gives us a comparison of cost which is favorable to the Salerno Process.

Making of the tools. Two sorts of drawing dies were made. One of high speed steel held in a rim of medium steel, the other a chilled cast iron die. (Figs. 6 and 7.)

The steel dies are turned out, hardened, and the outside rim is shrunk on, the rim beng left soft. These dies are rather expensive. In Rome, where the largest Salerno plant is situated, they are using chilled cast iron dies entirely. These dies are cast in a metallic die (Fig. 8), and the hole is simply polished with a piece of wood, and some emery.

The Italians claim that the cast iron dies are quite as good as the steel ones, but this has not been tested at St. Etienne Arsenal.

Expanding tools. (Fig. 9.) They are made of tool steel drawn to 5.85 mm. in diameter. The olive part is then upset on a Thompson electric welding machine. The part to be increased is held in the jaws of the machine, the current turned on and when it is sufficiently heated the jaws are closed on each other and the bar swells out. The operation is very rapid. The swollen part, about 9 mm. in diameter, is turned down to the proper shape and polished, heated to a cherry red, and hardened in water. The temper is drawn to a yellow straw color. When finished they are marked with a diameter of the largest part.

Comparative Results of Trials

The experiments have been made on 8 Hotchkiss barrels from steel of different origins:

4 barrels fitted with tubes of—
No. 1. Holtzer steel, non-hardened;
No. 2. Holtzer steel, hardened;
No. 3. Chambert, non-hardened;
No. 4. Girod, non-hardened.

2 barrels—
No. 5. The metal of which was provided by the Hotchkiss Company;
No. 6. The metal of which was provided by the Hotchkiss Company.

2 barrels—
No. 7. The metal being taken from the St. Etienne stock;
No. 8. The metal being taken from the St. Etienne stock.

All these barrels have been submitted to the same tests, each proof-firing consisting of 3 consecutive bursts of 200 cartridges with regulation ammunition, fired at intervals of 2 minutes counting from the beginning of a burst to the beginning of the next. Complete cooling after 600 rounds.

The wear of the barrels has been checked every 1,200 shots by a burst of 24 cartridges fired with a cold barrel at a target situated 200 meters away. Not more than 24,000 rounds have been fired from any one barrel.

After they have fired 24,000 rounds, the No. 1 and No. 2 barrels still gave round bullet holes at 200 meters.

No. 3 barrel gives tilted bullet holes after 24,000 shots
No. 4 barrel gives tilted bullet holes after 14,400 shots
No. 5 barrel gives round bullet holes after 24,000 shots
No. 6 barrel gives round bullet holes after 18,000 shots
No. 7 barrel gives round bullet holes after 21,600 shots
No. 8 barrel gives round bullet holes after 24,000 shots

This process seems to be very interesting and I am of the opinion that, if modified as circumstances might require, it could be used for relining guns of larger caliber as well as small arms, and a process of relining field guns by some such method as this might perhaps result in a very large saving of costs as well as a large saving of time, both of which are important in war-time as well as in peace-time.

The French were particularly pleased with the process as it was very well adapted to the repairing and saving of barrels of the Hotchkiss machine gun.

The Italians converted practically all their 11-mm. guns to the 6 mm. size by this process. They got perfect adherence of the tubes without even boring the rifling out. While I have not seen these barrels personally, I have been assured that the Italians had no trouble of any kind with them.

One of the private gun manufacturing firms at St. Etienne offered to reline small arm barrels in this manner at a cost of $4.00 per barrel, agreeing to turn out 500 barrels per day. It must be understood that these were war-time prices and when used as a basis of comparison this must be taken into consideration. There is no apparent difference in the length of life a re-tubed barrel and that of a new barrel.

Characteristics and Analysis of Metals Employed for the Tubes

	Holtzer Metal		Girod Metal		Chambert Metal
Tensile strength, Kgr. per sq. mm.	62.2		86.2		89.9
Average elongation, per cent (Specification)	22.75		17.8		8
Carbon 0.55 to 0.7 per cent	0.655	0.620	0.599	0.59	0.592
Manganese 0.75 to 0.95 " "	0.862	0.665	0.480	0.490	0.870
Silicon 0.3 to 0.5 " "	0.545	0.559	1.80	1.770	0.501
Sulphur less than .003 " "					0.034
Phosphorus less than 0.04 " "	0.020	0.020	0.016	0.017	0.014

Artillery Division Notes

The St. Chamond Recoil Mechanism

A recoil mechanism must absorb the energy of recoil and gradually bring the gun to rest; absorb the energy of counter recoil and return the gun from its recoiled position to its in-battery position without shock, and hold the recoiling parts in battery at maximum elevation.

The St. Chamond recoil mechanism has fulfilled these conditions. This mechanism was developed during the war in 1917 for the 75-mm., 1916 American Carriage by Col. Rimailho of the French Army at the St. Chamond factory.

It is of the hydro-pneumatic type, and is smooth in operation and durable. Further, the use of small forgings for carriages, ranging between 3-inch and 4.7-inch inclusive, is made possible by the use of high pressures in the recoil and recuperator cylinders. The success of this recoil mechanism may be attributed to the development of a specific packing which would hold high pressures, and the function of counter recoil.

Figure 1 is an assembled view of the St. Chamond brake as used on the 75-mm. gun carriage, M. 1916MI. There are three cylinders, the middle one being the recoil or hydraulic cylinder, the right cylinder has an air chamber at its forward end, and an oil reservoir at the rear end. The left cylinder, known as the recuperator cylinder, comprises at its forward end additional air space and has at its rear end the floating piston and regulator for controlling the length of recoil.

The recoiling parts are held in battery by the reaction of air on a floating piston and liquid against a leak-tight recoil piston head, using one piston rod for both the function of recoil and counter recoil, the floating piston separating the oil from the air. An opening is provided between the recoil cylinder and recuperater cylinder, in which a regulator valve is placed.

Figure 2 shows a schematic diagram of the operation of the St. Chamond system for both recoil and counter recoil.

In recoil the gun moves to the rear carrying with it the recoil piston (middle cylinder). The pressure in this cylinder opens the regulator valve, the movement of which is controlled by a small coil spring in parallel with Belleville washers. Thus the energy of recoil is absorbed by throttling the oil through this spring-controlled orifice. The oil passing through the recoil orifice moves the floating piston forward against the air, thereby increasing the air pressure and storing up energy, which returns the gun. During recoil the oil pressure in the recuperator cylinder is higher than air pressure, this drop being due to the floating piston friction. The counter recoil valve remains closed during recoil.

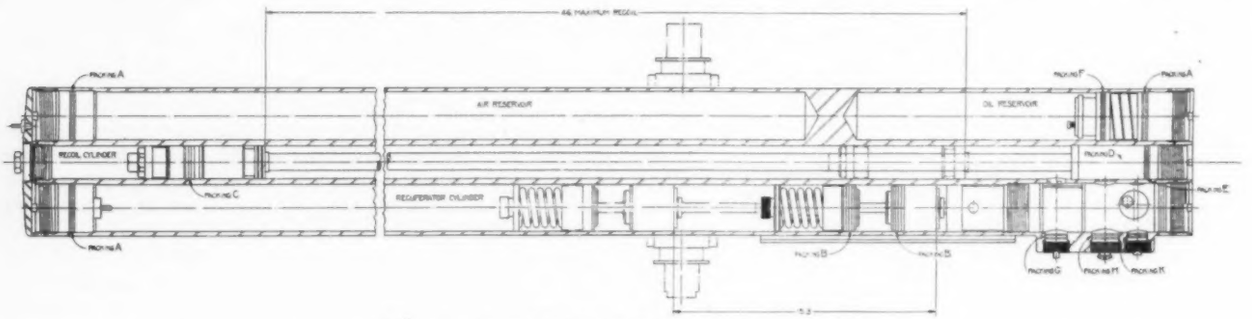


Figure 1. Assembly of 75 mm. Recoil Mechanism, 1916 M. I.
Initial Air Pressure 1,000 lbs. per sq. in. Maximum Air Pressure 1,500 lbs. per sq. in.
Maximum Hydraulic Pressure 5,250 lbs. per sq. in. Resistance to Recoil at 0-degrees Elevation 4,000 lbs.
Maximum Resistance at 53-degrees Elevation 12,000 lbs.

The recoil regulator valve is closed during counter recoil. The oil flow during counter recoil, therefore, is different from recoil. The flow path is through a small channel (Wo) at the inside end of the buffer chamber in the recuperator cylinder and ending in the hydraulic cylinder, as shown in Figure 2. The throttling during counter recoil takes place through a constant orifice at the beginning of the counter recoil channel. The pressure (Pa) on the oil side of the recuperator is lowered by this throttling to a small pressure in the recoil cylinder. The tapering buffer rod on the floating piston in the recuperator causes additional throttling through the annular area between the buffer chamber and buffer rod of the floating piston. Toward the end of counter recoil, the pressure in the recoil cylinder is thus brought to practically zero. The constant throttling area in the counter recoil channel is so designed as to cause sufficient throttling to lower the pressure in the recoil cylinder that it may practically balance the total friction, guide and stuffing box, during counter recoil. At the end of counter recoil this friction alone brings the recoiling mass to rest when it reaches the battery position.

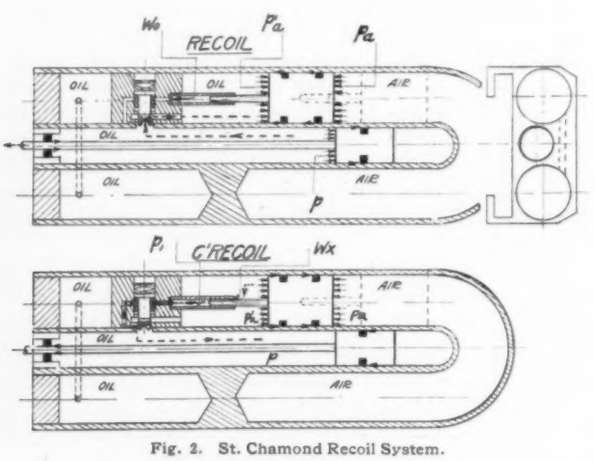


Fig. 2. St. Chamond Recoil System.

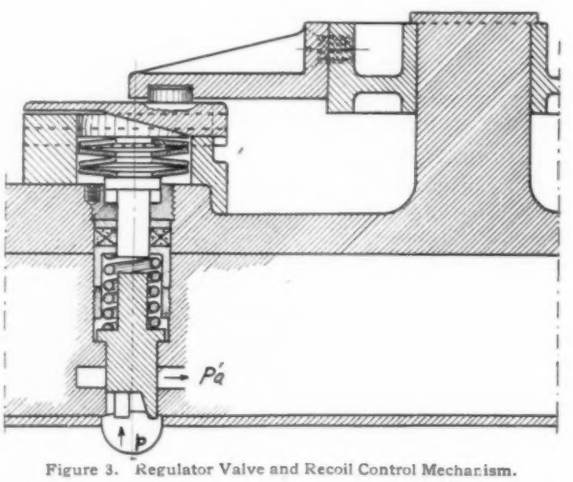


Figure 3. Regulator Valve and Recoil Control Mechanism.

The essential feature of the St. Chamond brake is the spring regulated valve where the main throttling occurs. The valve functions somewhat as a pressure regulator since if the pressure is lowered the spring reduces the valve opening thereby increasing the throttling drop and the pressure in the hydraulic cylinder. The pressure in the recoil cylinder is the sum of the air plus the floating piston friction drop plus

the throttling drop through the regulator valve. At short recoil the air pressure is small compared with the throttling drop. The resistance to recoil is large and therefore the recoil pressure large. This requires a large throttling drop and the air pressure becomes small compared with the throttling drop. A large throttling drop requires a very small opening with a large pressure reaction against the valve. To balance this reaction a very stiff spring is required. Such spring characteristics have been met by the use of Belleville washers. At long recoil the resistance is small, therefore the throttling drop is small and requires a large orifice. Since the pressure in the recoil cylinder is small together with a large orifice opening, a weak spring with a large deflection is desirable. Such spring characteristics are best met with an ordinary spiral spring. Hence at long recoil, low elevation, a spiral spring functions alone, while at short recoil maximum elevation, the belleville and spiral spring function in parallel. (Figure 3.)

At short recoil the upper stem of the regulator (Fig. 3) is brought down by the cam at its top until its lower surface is in contact with the top surface of the lower valve stem. Thus the length of recoil is automatically varied by the control mechanism (Fig. 3).

Rock Island Arsenal Notes

Experiments to Determine the Proper Method of Riveting the Larger Duralumin Rivets

Considerable use is being made of duralumin for the bodies and some other parts of the 600 and 900-pound tractor power carts and for the 800 and 1600-pound reconnaissance tractors now being manufactured at this Arsenal. Many Lynite (aluminum casting alloy) castings are also called for in these designs.

The attempt to follow ordinary riveting practice for riveting together the body sheets and some of the Lynite castings was successful only when the smaller duralumin rivets, less than ¼-inch, were used. The larger size, such as the 5/16-inch rivet, gave considerable trouble; the shank bending; heads incomplete and poorly formed; and breakage of the Lynite castings while attempting to form the rivet. Since duralumin becomes increasingly hot short when worked above 800 to 850 degrees F., the use of a hot rivet is impossible. The attempt to drive duralumin rivets directly after removal from a furnace maintained at 800 degrees F. gave no beneficial results since the duralumin or Lynite to be riveted conducted the heat away from the rivet so rapidly that it was impossible to hold the rivet at the better working temperature during the process of riveting.

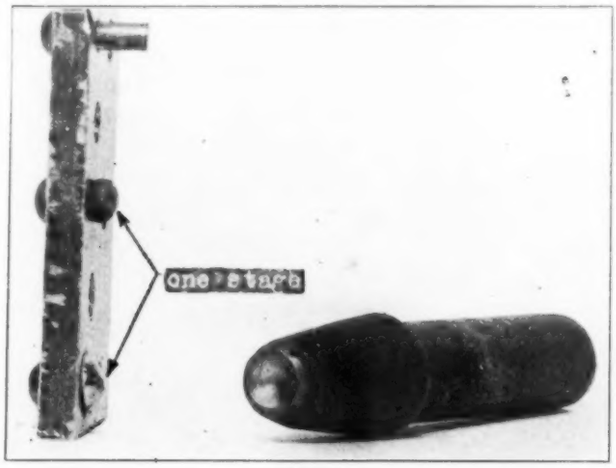


Figure 1

The use of a hot steel rivet or an electrically driven rivet was also tried but the results are not considered desirable because the steel rivet attains a temperature above the melting point of the duralumin, and the dissimilar metals allow of rapid corrosion due to galvanic action.

Experiments were then conducted with a view of finding a method of driving the larger duralumin rivets so as to get a perfect head, to prevent cracking the Lynite castings and to be applicable to quantity production.

The last requirement, that of quantity production, did not seem within reach because hand riveting was first employed giving heads which appeared acceptable upon general examination but when sectioned, polished and etched the discontinuity of the flow lines of the metal in the point head indicated that it would not stand the maximum loads. The desires to secure a correct head and at the same time prevent cracking of the Lynite casting appeared, at first, inconsistent, since a large riveting hammer was necessary to form a head with the ordinary button set and this large hammer with 90 pounds air pressure at the main line always split the Lynite. It was decided, therefore, to develop a modified rivet set so that smaller hammers and lower air pressures could be used and still secure the desired head. Many rivet sets of varying form were made and used and the minimum air pressure and correct hammer determined for each. The button head point was formed in all cases. The method and tools adopted are discussed below.

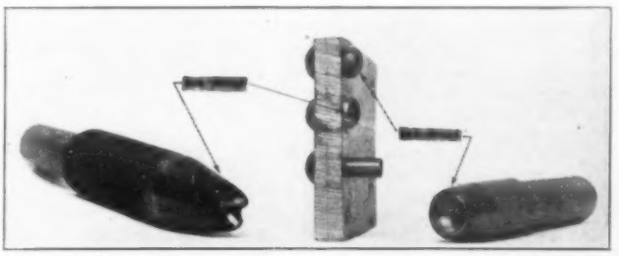


Figure 2

Either annealed duralumin rivets or heat treated rivets can be used. If the heat treated rivet is essential, for instance, where the maximum strength is required, it must be driven immediately following the quench. The annealed rivet is in its softest condition and unless the heat treated rivet is worked immediately after the quench it will be found to have hardened enough so that it cannot be satisfactorily riveted. Further, the annealed rivet is strengthened noticeably by the cold working to which it is subjected. A shearing test on 5/16-inch duralumin rivets, single shear, driven in steel plates 7/32-inch thick gave a maximum load of 21,000 pounds per square inch for an annealed rivet and 34,000 pounds per square inch for the heat treated rivet driven immediately following the quench and aged. The value of the heat treated rivet is roughly 1.6, or, if four heat treated rivets are required for a certain fastening, it may be said that six annealed rivets will accomplish the same purpose. Since the annealed rivet is cheaper and the same purpose. Since the annealed rivet is cheaper and presents fewer difficulties to drive, the general use of the annealed rivet is recommended.

Holes for duralumin rivets should be drilled and reamed to size; i.e., a hole for a ¼-inch rivet should be drilled 1/64-inch small and reamed at assembly to ¼-inch. In general it may be said that rivets should "tap fit" their holes. Should the holes be larger than this, the tendency of the rivet to pull and drive off center is increased.

All the experimental rivets were driven through Lynite castings and the air pressures determined upon are not great enough to cause the casting to split. If two pieces of duralumin are riveted together, the air pressures used can, of course, be greater.

Hand riveting may be employed in the smaller sizes quite successfully. For the larger rivets referred to above, the head, although of acceptable general appearance, is not as sound as those produced by the special rivet set and pneumatic hammer. The 3/16-inch rivet can be driven with the ordinary set and in one stage. The No. 18 Ingersoll-Rand Hammer and 60 pounds of air pressure are used. (Fig. 1.)

The ¼-inch rivet requires a No. 18 Ingersoll-Rand Hammer, 60 pounds of air and an ordinary ¼-inch set for the first stage. The "button" produced in the first stage is clearly shown in Fig. 2. The first stage is quite readily secured and as soon as the operator feels that the rivet is no longer flowing into the button shape readily and is offering increased resistance, he should stop and finish and form the head with the four-way set shown in the illustration. This set is made with a knurled body so as to allow the operator to grasp and "spin" it during the final stage of driving the rivet. It is

this relieved set rotated during the operation that allows the head to be formed with the low pressures used. The experiments have shown that the Lynite casting when struck with the rivet set during the riveting willl deform but does not crack.

The 5/16-inch rivet requires a No. 28 Ingersoll-Rand Hammer, 60 pounds of air and the ordinary 5/16-inch set for the first stage. The second and finishing stage utilizes a five-way set which is shown in Fig. 3 which is "spun" in operation. It is essential that the special sets used be rather rapidly rotated by the operator to prevent unnecessary marking of the finished head. If properly done the head will be perfectly smooth as shown in the photographs. The air pressures should not exceed those given above when the rivet passes through a Lynite casting. Lynite, the experiments have shown, will crack readily if the heavier hammers and maximum air pressures are employed. In all cases the hammer must be held in line with the rivet and the air applied rather rapidly to form the first stage or the shank will bend and it will be found necessary to replace the rivet. The operator must develop a certain amount of "knack" or the rivets will drive off center by an amount too great to be allowed. If a heat treated rivet is driven immediately after the quench about twenty pounds more air than the pressures recommended will be found necessary in order to properly form the head.

Since the rivet is to be a tight fit in its hole, the amount of shank necessary to form the head will be more or less constant and not dependent upon the grip or thickness of the material riveted together. For the 3/16-inch rivet, 5/16-inch of shank plus the grip is necessary to form the head. For the ¼-inch rivet, 7/16-inch is necessary and for the 5/16-inch rivet, ½-inch is necessary.

The pitch, the distance of rivet from edge of plate, the clearance, etc. may well follow good structural riveting practice. In Lynite castings, the distance of the rivet from the

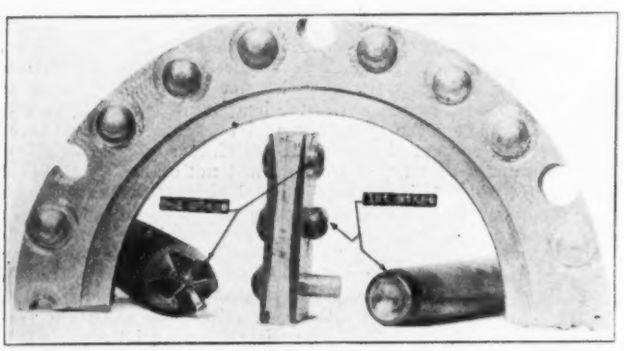


Figure 3

edge of the casting should be at least two diameters of the rivet.

The advantages of the method discussed above for the larger rivets are that the hammers ordinarily carried in stock are used without modification and a simple air reduction valve serves for one or more hammers as is desired; the special sets used are durable to manufacture; the chances of breaking the casting are largely done away with; the "knack" required to produce desirable rivets is easily developed by the ordinary riveter; and a finished and sound head is secured in no greater time than that required for steel riveting.

Frankford Arsenal Notes

New Elevation Quadrant for Machine Guns.—The present method of controlling machine-gun fire at high angles is by means of the Machine Gun Clinometer, Model of 1917 (Figure 1).

This is a small portable instrument, consequently liable to be mislaid or lost, somewhat inconvenient in that it requires two hands to operate and necessarily has to be removed from the gun during firing and replaced when the gun is to be relaid. These defects seriously retard the rate of fire and the need of a more efficient method of laying machine guns has led to the development of the Elevation Quadrants, Types B and C, samples of which have been manufactured and sent to Camp Benning for test.

The Elevation Quadrant, Type B (Figure 2): The bracket for attaching the quadrant is permantly fastened to the left hand side plate of the machine gun. It carries a horizontal groove to receive the dovetail lug on the quadrant housing. A spring detent engages a notch in the lug and retains the quadrant in position.

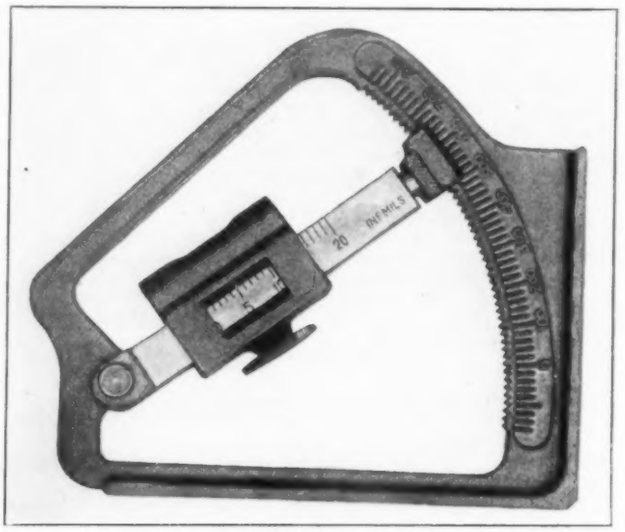


Figure 1

A clockwise rotation of the knob causes a movement of the level bracket such that when the bubble is brought midway between the graduations on the level vial, the gun is elevated a like amount.

Tightening the wing nut locks the micrometer in the desired position and prevents the rotation of the worm during firing.

The elevation scale is graduated into six equal spaces, each representing an angle of 100 mils. The middle graduation, numbered 3, indicates the zero of the scale, after the method

Figure 2

employed by the Field Artillery for angle of sight mechanisms.

Settings less than 300 mils indicate depression and above that, elevation. The micrometer is graduated into 100 equal spaces, each representing one mil. One turn of the micrometer advances the elevation scale one space or 100 mils, which corresponds to the graduations on the micrometer.

A cover is provided for protecting the level vial when the quadrant is not in use and can be readily adjusted or replaced by removing the screw plug in the level bracket.

The micrometer can be adjusted for zero conveniently, and means are provided for eliminating the effects of backlash between worm and worm wheel.

The Elevating Quadrant, type C (*Figure 3*), is similar to the Type B, except that the bracket for attaching the quadrant is secured to the right hand side plate of the machine gun and contains a vertical groove to receive the dovetal lug on the housing.

The elevation scale in the Type C instrument is graduated into six equal spaces, each representing an angle of 100 mils. The zero graduation designates the normal.

The micrometer is graduated into 100 equal spaces, each representing one mil, and numbered from 0 to 100 clockwise and contraclockwise. One turn of the micrometer advances the scale one space or 100 mils, which corresponds to the graduations on the micrometer.

The Machine Gun Panoramic Sight, Model 1918 (Figure 4) is issued to machine gun organizations for determining firing data for use in directing machine gun fire.

The needs of the service for a more efficient method of aiming a machine gun, especially at marked objects—which method of fire is commonly known as indirect fire—suggested the use of the Machine Gun Panoramic Sight, Model 1918, for this purpose. Several Browning machine guns were equipped with brackets for mounting the sights and a series of experiments were conducted, which demonstrated the practicability of using panoramic sights for such purposes.

The Machine Gun Panoramic Sight, Model 1918, was designed principally for mounting on a tripod for field use and its construction was necessarily light so as to be readily handled and transported. During the test a number of objectionable characteristics and weaknesses became apparent, particularly that of the rotation of the azimuth and elevation mechanisms during firing, which caused errors in fire and inconvenience to the gunners. With a view of securing an instrument adapted for such use, the Quadrant Sight, Model E, has been developed and is being constructed for test by the Infantry Board at Camp Benning.

The Quadrant Sight, Model E (*Figure 5*) consists principally of a Panoramic Telescope, the elbow portion of which contains a cylindrical collar, having worm teeth, which is mounted in the bearing portion of the Worm Housing. The Elevation Knob attached to the end of the elevation worm, when rotated, causes the rotation of the telescope.

The optical elements of the Panoramic Telescope are arranged similarly to those of the Panoramic Sight, Model of 1917, and have the following optical characteristics:

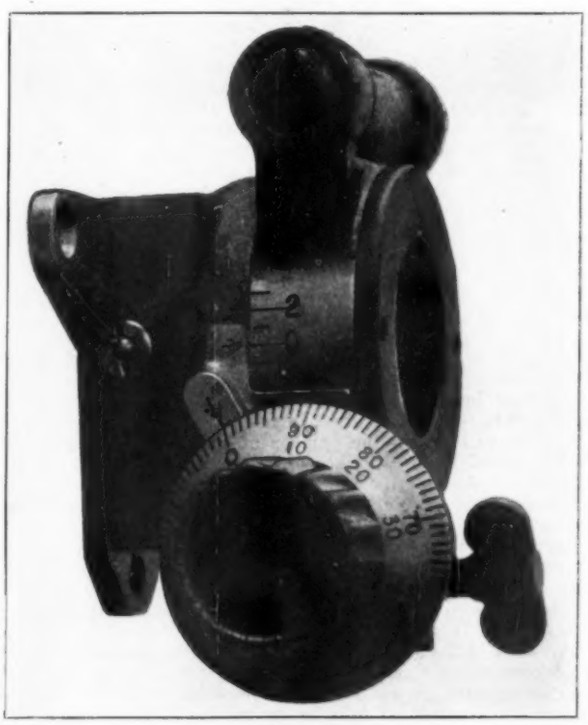


Figure 3

Power	3
Field of view	13½°
Diameter of exit pupil	.15
Clear aperture of objective	.45
Effective focal length of objective	2.00

Figure 4

The azimuth scale is graduated into 64 equal spaces, each representing 100 mils of angle and numbered from 0 to 64.

The azimuth micrometer is graduated into 100 equal spaces, each representing 1 mil and numbered every 10 spaces from 0 to 100. One turn of the micrometer advances the elevation scale one space or 100 mils, corresponding to the graduations on the elevation micrometer scale. The eccentric lever when rotated and held, permits free rotation of the rotating head, for rapid setting.

The elevation scale is attached to the cylindrical portion of the elbow of the panoramic telescope and is graduated into 8 equal spaces, each representing an angle of 100 mils and numbered from 0 to 8.

The elevation micrometer scale is secured to the worm housing and is graduated into 100 equal spaces, in a half circle, each representing an angle of one mil and numbered from 0 to 100.

The range scale is secured to the end of the elevation worm and is graduated in yards range and contains two arrows engraved diametrically opposite each other for use in connection with the elevation micrometer scale. One turn of the range scale advances the elevation scale two graduations or 200 mils.

It will be noted that at all times one of the indexes on the range scale will be indicating opposite the graduations on the elevation micrometer scale. It is by this means that single mils are recorded in conjunction with the elevatoin scale.

The angle of sight scale is graduated into 200 equal spaces, each representing one mil and numbered every ten from 0 to 100 clockwise and contraclockwise. It can be rotated free of the other scales and carries with it the angle of sight index.

Since one rotation of the elevation worm causes an advance of 200 mils of the elevation scale, it is obvious that the range scale can only be graduated to a range corresponding to an elevation of 200 mils or a range of approximately 2,550 yards.

To lay the machine gun in elevation corresponding to an angle in mils, rotate the elevation knob until the elevation scale index and an index on the range scale indicate the desired

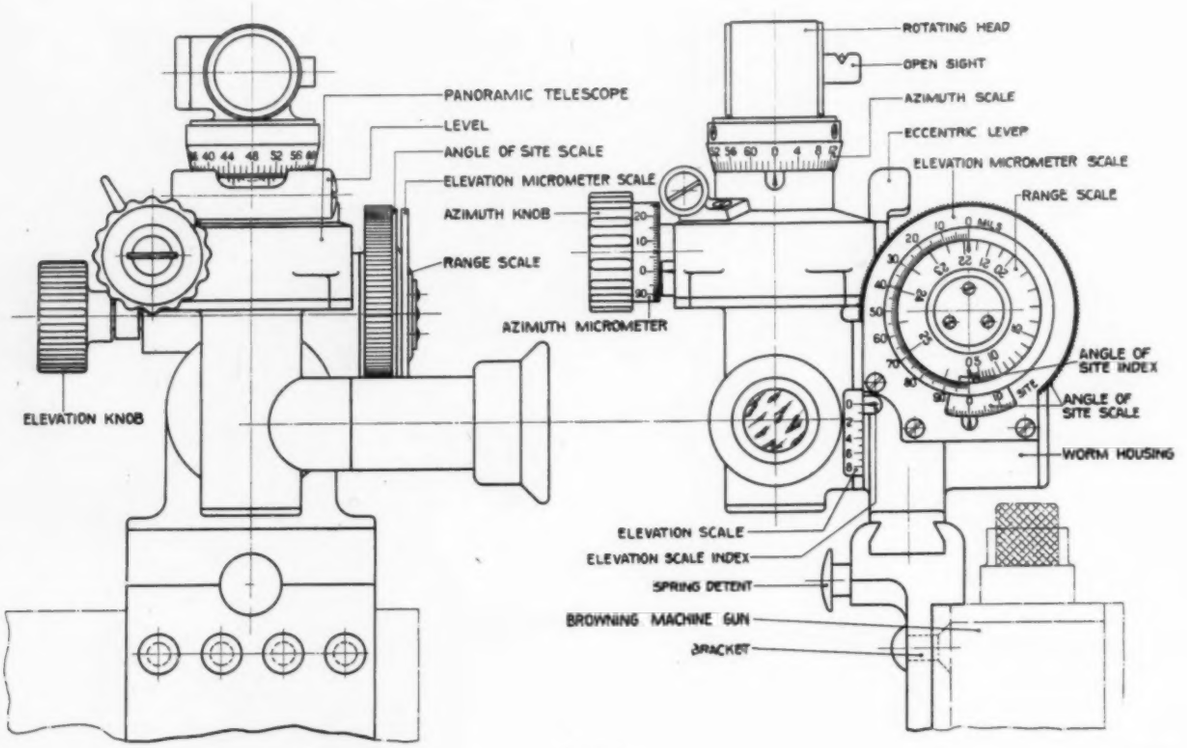


Figure 5

elevation then lower the machine gun until the bubble is midway between the graduations on the level vial.

To lay the machine gun in elevation by means of the range and angle of sight scale, rotate the angle of sight scale to the setting indicating the angle of site, then rotate the elevation knob until the range is opposite the angle of sight index. Then lower the machine gun until the bubble is midway between the graduations on the level vial.

The lower portion of the worm housing contains a dovetail lug for attaching the quadrant sight to the bracket secured to the machine gun. It is held in position by the spring detent.

Watervliet Arsenal Notes

Rifling of Cannon.—Prior to the World War it was the practice to rifle seacoast cannon with a rifling head containing

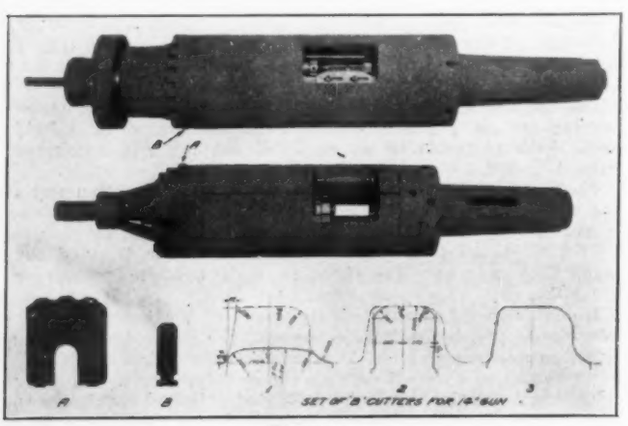


Figure 1

not more than four cutter blocks. Each of these blocks was ground to carry three cutters each, which made it possible to cut twelve grooves with one set-up of the rifling head. The slowness of the operation retarded production to the extent that a radical improvement in the practice of rifling large cannon was absolutely necessary.

Prior to the first part of the year of 1917 rifling heads used on cannon with a bore of 6 inches or less in diameter could not carry more than two cutters per block while the radial angle on guns of 3 inches in diameter and under prevented more than one cutter per block.

The existing rifling heads for small caliber field guns had the feed arrangements, cutter adjustments, screws, etc., carried in the front of the head occupying space which could be used to advantage in providing a greater number of cutting tools.

In order to remove the bottle-neck from production, a new rifling head for rifling 75 mm. cannon was designed at this arsenal in the early part of the year 1917. The particular points of advantage secured in this new design of rifling head are as follows:

It carries four cutters instead of two; the cutter expanding device is located to the rear of the head and controlled by a graduating nut. Access to this nut is obtained by an opening in the side of the head thereby permitting adjustment of the cutters without withdrawing the entire rifling head from the bore of the cannon and thus shortening the travel of the head for each cutting stroke.

The bronze sleeve is assembled from the rear thus permitting a saving of approximately eight hours labor in replacing a worn-out sleeve. The side-play of the cutter slides is adjusted by a bronze gib having contact with the full length of the slide instead of one point contact as in the previous designs.

The most notable advance in reducing the time required for rifling guns of large caliber was the development of the White rifling head. This uses the same feed idea as the 75 mm. rifling head just referred to but differs in the method of holding the cutters. It permits the assembly of any number of cutters up to one-half the number of grooves in the gun and removes metal from alternate grooves at each passage of the rifling head through the gun. Rifling heads of this type are now being used at Watervliet Arsenal for the rifling of large caliber cannon with great success.

The rifling head proper consists of a cast-iron body with a tapered shank which fits the rifling bar. Over the cast-iron body there are fitted four bronze shoes, the diameter of which can be adjusted as the shoes wear and regrinding becomes necessary.

The head is designed to cut one-half of the required number of grooves at each setting: individual cutters being provided for cutting each groove. These cutters are assembled to and expanded or contracted radially by the tool-carrier which con-

sists of a sliding steel ring assembled to the main shaft of the rifling head.

The tool-carrier is provided with a series of tee slots cut at an angle of 1° 30′ with the axis of the shaft upon which it slides. The rifling cutters are fitted into these tee slots. By moving the tool-carrier to the rear, the rifling cutters are contracted. By moving the tool-carrier forward they are extended. This movement provides a means for retracting the cutters on the return stroke of the rifling bar.

At the front end of the rifling head and directly over the sliding tool-carrier there is a steel guide ring which contains a series of radial slots which guide and support the rifling cutters. Oil holes are provided in the front of each slot through which cutting oil is forced onto the cutting edge of the rifling cutter when in operation.

At the front of the rifling head a shaft or plunger projects which when forced in, carries back the tool-carrier retracting the cutters and, when moved forward, carries the tool-carrier with it expanding the cutters. The rifling cutters are adjusted or fed out radially to accomplish the desired depth of cut by means of a nut and screw in the side of the rifling head.

The White rifling head is the head shown in the upper view of Figure 1. The lower view in Figure 1 shows the old type rifling head with three cutters per block as used in rifling 4.7-inch guns.

The White rifling head has a particular advantage over the type used for rifling 4.7-inch guns in that the torsion of the rifling bar when in operation is more uniform, which makes it possible to rifle a gun with a minimum variation in the widths of the grooves at the origin of the rifling in the powder chamber.

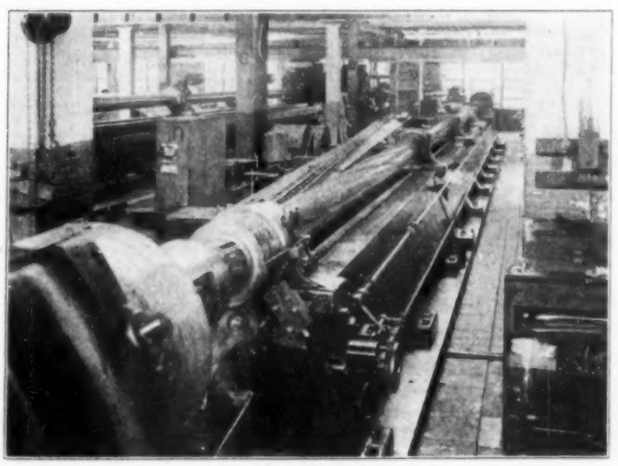


Figure 2

In the older type guns, rifling grooves were wide and shallow, but the newer guns call for rifling in which the width of the groove has been decreased in order to provide more land-surface; the depth being increased for the same reason until at the present time the depth of the groove in the larger caliber guns is almost equal to the width.

With a rifling head with the old type cutters it would be more difficult to cut a groove of the depth used at the present time without danger of breaking the cutter with a consequent damaging of the rifling. Therefore the cutter as used in the White rifling head is more adaptable to the present type of rifling as laid down for large caliber guns.

Three sets of rifling cutters are employed in the rifling operation on a 14-inch or 16-inch gun. These cutters are shown in sketch on Figure 1. The first cutter which is to the left of the sketch finishes the top radii of the grooves. The second roughs out the grooves to the required depth, while the third finishes the groove to the required form.

At "B" there is shown a cutter as used in the White rifling head while at "A" is shown the type cutter as used in the 4.7-inch rifling head.

Figures 2 and 3 show the type of rifling machine used at the present time in rifling at Watervliet Arsenal. The machine consists of a plain machine bed, one end of which is equipped with rests or cradles for supporting the gun which is to be rifled, the gun being held stationary; it does not rotate.

The other end of the machine is fitted with a bench which carries the rifling bar and movable housings; the forward end of the bar carrying the rifling head.

The rifling head is shown assembled on the rifling bar in

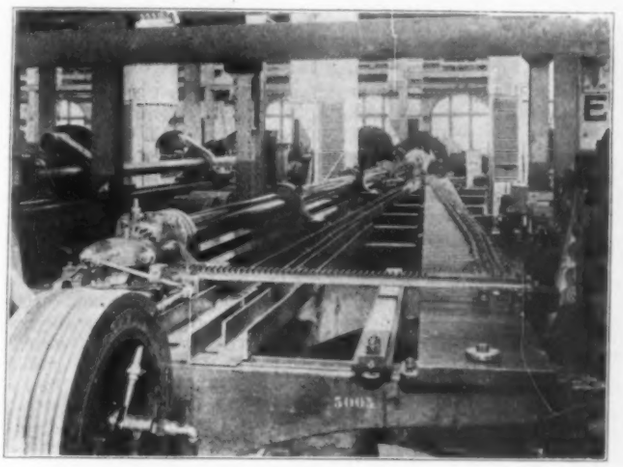


Figure 3

Figure 4. A gun ready to be rifled is shown on the left-hand side of the photograph.

At the extreme end of that part of the rifling machine which carries the rifling bar there is mounted a reversible motor which is controlled from the front of the rifling bar bench. This motor operates the rifling bar by means of a screw and nut. A reel of flexible steel oil hose is also located at the same end of the machine which unwinds and rewinds as the bar advances and returns. This hose is connected to a pressure oil pump at one end. The other end is connected to a pipe at the rear of the rifling bar which passes through it and is connected to the rifling head. Oil is fed to the rifling cutters through this pipe, an automatic shut-off being provided to stop the flow of oil on the return movement of the bar.

Back of the rifling bar bench is located the ribbon bench which supports an adjustable plate with a series of dogs and adjusting screws which carries a flat steel bar ⅝ by 3 inches standing on edge between the dogs and the adjusting screws. This bar is called the rifling ribbon, the purpose of which is to generate the rifling curve rotating the rifling bar by means of a rack equipped with rollers which fits the sides of the ribbon and meshes with a pinion on the rear of the rifling bar.

The ribbon is set to the desired curve from the axis of the rifling bar which in guns of uniform twist is a simple helix angle corresponding to the twist desired. In guns having an increasing twist the curve when developed on a plane surface forms a semi-cubic parabola.

The purpose of the ribbon as before stated is to impart the desired rotary motion to the bar so that as the bar carrying the rifling head moves forward through the gun a curve of the

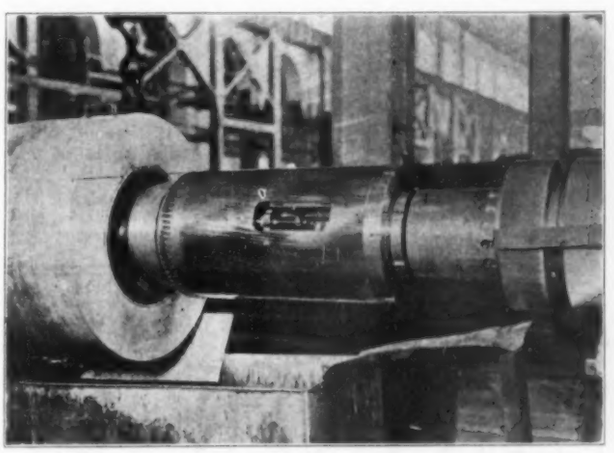


Figure 4

proper twist may be generated. This ribbon is, however, seldom used to perform the actual rifling operation due to the

wear that would result thereon from constant use. The ribbon and rack are generally used only for generating a groove or slot in the rifling bar itself (see Figs. 2 and 3 showing grooves in bar) which is accomplished by temporarily attaching a tool slide and cutter to the front end of the rifling bench and permitting the bar without rifling head and supported by bronze bearing rings to pass through the gun while the curve or groove is being cut in the bar.

When the curve or groove has been cut in the bar the rack connecting the ribbon and the rifling bar is removed from the machine and a stud fitting into the groove in the bar is inserted in the front housing which rotates the bar as it advances.

When a gun is to be rifled it is placed in the rests or cradles previously mentioned with the muzzle end toward the rifling bench and properly aligned with the bar so that the rifling head will pass through the gun freely together with the rings which support the bar at intervals along its length. After the gun has been properly aligned, the rifling head without the cutters inserted is carefully passed through the gun to insure perfect freedom. Then the cutters, all of which are ground exactly alike and therefore interchangeable, are inserted in the rifling head and adjusted so that when the cutters are fully extended they will pass through the bore of the gun without cutting. The stop for collapsing or retracting the cutters and against which the plunger on the front of the rifling head previously described acts, is set in the powder chamber of the gun and adjusted so that the cutters will be collapsed at the proper time. The stroke of the rifling bar is also adjusted so that the bar will be automatically brought to a stop at the proper point.

After the cutters and stops have been properly adjusted the cutters are carefully fed out by means of the cutter feed screw on the side of the rifling head until they begin cutting; this must be carefully done and the bore constantly observed to determine whether all cutters are functioning properly.

When the operator has assured himself that everything is functioning properly the cutters are then fed out according to the type of cutter and form of rifling being cut, the feed used being dependent on the conditions involved.

In rifling 14-inch and 16-inch guns having a groove as shown in Figure 4, a feed of .0015-inch per cut is used for cutters Nos. 1 and 2 and .003-inch per cut for cutter No. 3, except when within a few thousandths of full depth the feed is reduced to .0005-inch to insure a smooth and perfect finish.

The cutting speed used is approximately 14 feet per minute, which speed is approximately doubled on the return stroke. The cutting lubricant used consists of one part pure lard oil and two parts kerosene and is sprayed on the cutters during the forward movement of the bar; the expended oil returning to the oil reservoir from where it is forced under pressure through the bar to the cutters as previously described.

At the end of each return stroke the cutters are all carefully examined by the operator to insure that no damage has occurred to them and all adhesions of metal are removed with a copper scraper. The cutters which have been collapsed by the stop in the powder chamber are again expanded or set out to the cutting position by the operator moving forward the tool-carrier previously described, by means of a small bar which is used as a lever fulcrumed from the slots in the rifling head under the feed screw, two of which may be seen in the rectangular opening in the rifling head shown in Figure 4 and the operation continued as before.

When one set of grooves has been cut to full depth the head is indexed to the proper location for the second set of grooves by withdrawing the locating pin from the index ring in the front housing (see Figure 2) which carries the guide pivot for generating the curve and revolving the index ring until the corresponding slot coincides with the locating pin which is inserted and the operations as previously described are repeated.

Owing to the light construction of the rifling machine in use at the present time it is impossible to utilize the White rifling head to its full capacity and therefore only one-half of the total number of cutters are inserted, leaving out alternate cutters. This practice therefore requires the rifling operations to be performed in four settings rather than two. A new rifling machine is, however, now being installed which will be capable of using the "White" head to full capacity.

Watertown Arsenal Notes

Physical Properties of German Field Guns.

Investigations recently completed at the Watertown Arsenal on the physical properties of certain German field guns have shown very interesting information regarding the quality of steel in both pre-war and war production.

Complete tests were made upon the major component parts of both the cannon and the carriages. A digest of these in so far as they apply to the tube and jacket is given in the following tables.

The 77 mm. field gun was manufactured in 1915, the 105 mm. howitzer in 1899, the 155 mm. howitzer in 1917, and the 150 mm. gun in 1918. Charpy tests were made on 10 by 10 by 55 mm. bars notched on one side at the center to a depth of 5 mm. with a 1-mm. notch. These were broken on a standard kilogram meter Charpy machine. The Brinell hardness impressions were obtained with a 10-mm. ball 3,000 kilograms pressure held for 30 seconds.

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155 mm. Gun 8-inch Howitzer Carriage Model 1920

An experimental long range mobile artillery carriage has been recently completed by the Ordnance Department at Rock Island Arsenal and is now at the Aberdeen Proving Ground, Maryland, for test. This carriage, known as the 155 mm. gun, 8-inch howitzer carriage, Model 1920, mounts either a 155 mm. gun or an 8-inch howitzer. The cariage is of the split-trail type with rubber-tired wheels and permits a total movement of the cannon in azimuth of 60° and a maximum elevation of 65°. The recoil mechanism is of the hydro-pneumatic type with a variable length of recoil. In order to increase the rapidity of fire and ease of loading the cannon when firing at high elevations a quick release mechanism is provided for returning the cannon to the horizontal for loading without disturbing the sighting mechanism. The maximum range of the gun with a 95-pound projectile is over 14½ miles and of the howitzer with a 200-pound projectile is over 10½ miles. These ranges are about 4 miles longer than those obtained with similar artillery of the same caliber during the World War.

The weight of one cannon and carriage in firing position is about 24,000 pounds. For road travel the total weight of one vehicle is lessened by transporting the cannon, which weighs about 9,000 pounds, on a separate wagon, although the carriage may be moved for short distances with the gun mounted on it. While the range of these cannon is greater than that that of World War cannon of the same caliber, the weight of the assembled unit is actually less.

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Physical Properties of German Field Guns

Gun	Component	C	Mn	P	S	Si	Ni	Cr	W
77 mm. Field Gun	Tube	.31	.26	.029	.041	.203	2.81	.99	--
	Jacket	.21	.35	.022	.014	.183	5.73	.02	.42
105 mm. Light Field Howitzer	Tube	.29	.32	.024	.015	.225	5.55	.11	.60
	Jacket	.51	.21	.010	.033	.260	3.12	1.50	--
150 mm. Heavy Field Howitzer	Tube	.44	.22	.022	.043	.228	2.78	1.29	--
	Jacket	.34	.28	.036	.059	.250	2.67	1.21	--
150 mm. Field Gun	Tube	.47	.34	.030	.037	.193	3.03	1.54	--
	Jacket	.37	.18	.034	.049	.208	3.01	1.19	--

Gun	Component	Location of Test	Elastic Limit lbs. per sq. in.	Yield Point lbs. per sq. in.	Ultimate Strength lbs. per sq. in.	Elongation per cent	Red. of Area per cent	Charpy Notched Impact Test Ft.-lbs.	Brinell Diam.	Brinell No.
77 mm. Field Gun	Tube	Muzzle end, long	67,500	86,300	106,430	15.8	61.1	32.84	4.19	208
		Muzzle end, trans	60,000	78,000	104,500	20.4	61.7	21.61	---	---
		Breech end, long	64,150	72,350	100,630	25.3	64.7	32.64	4.29	198
		Breech end, trans	-----	78,830	102,800	30.5	59.0	23.51	---	---
	Jacket	Muzzle end, long	63,300	68,860	95,700	22.3	57.7	24.08	4.31	196
		Muzzle end, trans	-----	81,500	101,000	27.0	48.9	21.54	---	---
		Breech end, long	63,000	74,850	98,750	20.0	57.6	26.73	4.31	196
		Breech end, trans	64,850	70,030	97,480	23.0	49.8	15.12	---	---
105 mm. Light Field Howitzer	Tube	Muzzle end, long	-----	78,900	106,800	26.0	61.1	38.44	4.01	228
		Muzzle end, trans	-----	95,000	114,500	29.0	51.0	29.71	---	---
		Breech end, long	70,000	78,000	110,950	23.3	59.8	32.90	3.98	231
		Breech end, trans	50,000	79,500	111,000	14.3	54.8	23.95	---	---
	Jacket	Muzzle end, long	69,250	73,130	99,625	27.3	61.1	31.27	4.25	202
		Muzzle end, trans	-----	73,000	102,000	17.0	54.6	22.82	---	---
		Breech end, long	65,380	71,010	101,850	27.3	62.3	32.17	4.25	202
		Breech end, trans	62,500	69,580	112,430	21.5	44.4	22.82	---	---
150 mm. Heavy Field Howitzer	Tube	Muzzle end, long	-----	75,150	99,575	26.5	62.3	41.63	4.26	201
		Muzzle end, trans	-----	79,190	102,450	26.0	47.8	19.02	---	---
		Breech end, long	69,400	76,090	100,880	25.1	63.5	30.76	4.21	206
		Breech end, trans	65,000	74,850	100,800	21.0	46.5	17.32	---	---
	Jacket	Muzzle end, long	60,500	71,850	99,550	22.4	63.3	27.33	4.25	202
		Muzzle end, trans	-----	78,500	101,500	22.5	40.5	18.55	---	---
		Breech end, long	64,380	73,740	98,430	22.8	59.1	23.96	4.27	200
		Breech end, trans	65,000	71,750	96,730	18.8	46.1	16.32	---	---
150 mm. Field Gun	Tube	Muzzle end, long	65,000	69,000	111,550	22.8	53.3	30.25	4.00	229
		Muzzle end, trans	80,000	88,750	111,500	9.0	22.7	11.85	---	---
		Breech end, long	64,250	73,630	106,480	24.6	62.3	33.38	4.16	211
		Breech end, trans	60,000	70,580	104,000	15.3	27.1	15.07	---	---
	Jacket	Muzzle end, long	70,000	73,500	98,680	23.2	55.3	27.21	4.35	192
		Muzzle end, trans	68,000	73,660	97,530	8.5	19.1	18.06	---	---
		Breech end, long	69,000	72,560	96,060	24.3	60.4	28.41	4.33	194
		Breech end, trans	65,000	70,790	94,310	18.9	34.6	19.65	---	---

Springfield Armory Notes

Experiments are being conducted at Springfield Armory to obtain a satisfactory flash hider for the Browning Cal. .30 watercooled machine gun. German designs have been tested and modified to obtain better results; none have been found entirely satisfactory, although there are two types which have given good results.

Mr. W. R. Bull, of Springfield Armory, has produced a flash hider, the first model of which has given better result than any previous design tested at the Armory. The second model of the Bull hider is under construction in the shops and is expected to give results which will meet with the approval of the using arms of the service.

* * * * *

A magazine is under construction at Springfield Armory adatable to the Browning Aircraft Machine Gun Caliber .30, which contemplates the use of this gun on a flexible mount for aircraft armament. The magazine is attached to the top cover of the gun; it is light and quickly removed and the ordinary disintegrating metal belt is used in conection with the magazine and the feeding mechanism of the gun remains the same.

* * * * *

A new anti-aircraft mount of the .50 caliber Browning machine gun is under construction. This mount embodies no new type of construction or design.

* * * * *

Springfield Armory and the Veeder Company, of Hartford, Conn., have been developing a rounds counter for aircraft machine guns. The Veeder Company is following the usual design of counter type and at first encountered difficulty in making parts of sufficient strength which has now been practically overcome. The development at Springfield Armory has been along the lines of an indicator driven by a flexible shaft so that the indicator could be mounted in the most convenient place on the plane.

Some difficulties were met in the first model which necessitated a change in the design and a new design has been completed and is now ready for test.

* * * * *

The second sample U. S. Aircraft Machine Gun, Model of 1922, is now being assembled and will be ready for test during July. This gun embodies numerous improvements over the first model which was tested several weeks ago and is arranged for alternate right or left-hand feeding and right or left-hand location of the trigger motor and loading handle, these features are for the purpose of facilitating installation and are obtained without the use of extra parts.

* * * * *

The First Class, United States Military Academy, West Point, New York, consisting of 102 cadets, in charge of Lt. Col. Charles G. Mettler, Ordnance Department, Professor of Ordnance and Gunnery at the Academy, and Maj. Hubert G. Stanton, Ordnance Department; Maj. Arthur W. Ford, Ordnance Department; Maj. Oscar J. Gatchell, Ordnance Department; Maj. Edwin F. Harding, Infantry; Maj. Robert M. Lyon, Infantry, Maj. James A. Dorst, Engineers, and Maj. Harry N. Kerns, Medical Corps, were visitors at the Springfield Armory on June 2nd and 3rd, for the purpose of inspecting the work in progress.

They were conducted through the various departments, visited the Museum and an entertainment was arranged for their benefit on the evening of June 2nd, 1922.

They left for West Point on the afternoon of the 3rd in their special train.

* * * * *

Col. James J. Hornbrook, Cavalry; Col. Robert McCleave, Infantry, and Maj. Clifford Jones, Coast Artillery Corps, were at this Armory on June 22, 23, and 24, 1922 on a staff reconnaissance tour.

These officers composed a part of the section of twenty officers students of the Army War College, temporarily at Watervliet Arsenal, N. Y., who with Watervliet as their base are visiting other Army branches in New England for study, as a part of their course.

* * * * *

Five additional Browning aircraft machine guns, Model of 1919, have been constructed and tested. Various imperfections connection with the improvement of various types of ammunitional changes made in accordance with the desires of the Air Service. The next step in this project will be the production of a lot of 50 guns for extended tests by the Air Service.

"Dead-pressed" Explosives

Among the many interesting problems encountered by the Ordnance Department of the Army in its development work in connection with the improvement of various types of ammunition and their components, is the question of the proper density to which the various explosive components should be loaded in their respective containers.

The TNT or other high explosive used as a bursting charg ein high explosive or armor-piercing shell, or in airplane drop bombs, etc., must be compressed so as to obtain the maximum concentration of explosive energy in the given space. It is also well known that up to certain limits the rate at which a high explosive detonates is greater at high densities than when the explosive is not compressed, and since a high rate of detonation is of prime importance in determining the shattering effect of an explosive, it is apparent that high compression is desirable.

In armor-piercing projectiles there is another reason for a high density of the explosive. If the bursting charge is not sufficiently compressed, the very severe impact of the shell against an armor plate will cause a sudden forward movement of the charge within the shell, the resulting friction and heat being sometimes sufficient to cause premature detonation before the shell has passed through the plate. The explosion of an armor-piercing shell is supposed to take place *after* the shell has passed through the armor into the interior of a vessel, the explosion being brought about by a mechanical contrivance known as the fuse. The explosive component of the fuse is a detonator, which consists of a small charge of mercury fulminate pressed into a closed metal capsule.

Mercury fulminate is a very powerful and highly sensitive explosive and may detonate from even relatively slight shock or friction. If the charge in the detonator of an armor-piercing shell is not sufficiently compressed, the shock of impact of the shell causes premature explosion of the detonator, as a result of the friction of the shifting charge.

TNT and similar explosives used as bursting charges can be compressed to their maximum density without materially losing their ability to explode under the influence of the detonator, although their sensitiveness is appreciably reduced at high densities. Mercury fulminate, however, when highly compressed, loses entirely its ability to detonate when exposed to the flame from a primer or black powder fuse train, becoming "dead-pressed." This condition is sometimes obtained with pressures of 20,000 pounds to the square inch—a pressure which can be easily obtained with the presses used for loading purposes. When in this state the fulminate burns as harmlessly as a match on being ignited by a flame, although the experiment is not a safe one to carry out without elaborate precautions against mishap.

It is apparent from the above that in the type of armor-piercing shell fuses where the detonator is fired by means of the flame from a primer or from black powder, too great compression of the fulminate charge may cause complete failure of the detonator to function, while insufficint comperession may cause it to function prematurely before the shell has penetrated the plate.

Proposed Fixed Price War Time Contract

A committee, appointed by the Assistant Secretary of War and representing the procuring services of the War Department, has been working for a considerable period on standardized contract forms embodying the experience gained in the World War for use in the event of a national emergency. The present form deals only with contracts on a fixed price basis. The principal articles of this form are given below. Limitation of space prevents giving the complete form. At a later date, one or more forms on a cost basis will be prepared. In the preparation of the enclosed form the committee has attempted to remedy a number of difficulties and objections which developed in the execution of similar contracts during the war. It is believed that a statement of the most important of these points would be useful in the consideration of this draft.

First, the provision for payments under the contract have been made as elastic as possible in order to cover as many as possible of the necessities that arise in the progress of work. As written, the contracting officer is not limited as to the times at which he may make payments nor as to the amounts with the exception that the total of amounts paid shall not exceed his estimate of the percentage of completion of the contract, less amounts retained. For instance, if the total amount of the contract were $1,000,000 and the contractor had expended $50,000 in the proper preparation for work, the contracting officer could, if he were satisfied that the progress represented one twentieth of the entire work, pay the contractor $50,000 less 10 per cent, or the net of $45,000. By using the percentage of completion of the work rather than materials or other property purchased for the work as a basis of payment, many troublesome questions involving the accountability of this material are avoided.

Second, the termination article is intended to permit of the instant termination of work on articles no longer needed. The interests of the contractor on the one hand are safeguarded and, on the other hand, the troubles and difficulties that would arise from unexpectedly throwing great numbers of men out of employment are sought to be avoided or minimized by the provision under which the men so discharged will be paid for 45 days at two-thirds of the pay that they were receiving. This is equivalent to one month's full pay and affords them time and a reasonable amount of money with which to adjust themselves to new conditions. The termination clause also seeks to avoid the necessity of any settlement contract. By the power to stop work instantly on articles no longer needed, not only is a very considerable expense saved to the United States but it is believed that the process of getting back to peace-time work will be greatly hastened. Attention is also invited to the clause which permits a contractor to take over materials in his plant which are the property of the United States and which he desires for the resumption of his peace-time activity at an equitable price. It is, of course, entirely optional with him whether he takes any such material or not. It will also be noted that all references to liquidated damages for nonfulfillment of contract terms is omitted as not being necessary or suitable to the conditions of war work. The options reserved to the United States in the event of the failure of the contractor to perform satisfactorily are believed to be ample protection.

Third, the requirement that a contractor shall assemble cost in accordance with forms and methods to be prescribed by the War Department is believed to be very essential for the prompt and satisfactory settlements of any claims arising under the contract. It does not mean that a contracor must give up his own established cost accounting methods but merely that, in addition to assembling costs by his own methods, the same data shall be assembled on the forms and by the methods prescribed by the War Department.

The conditions under which war work is performed are entirely different from those in time of peace. The war contractor has comparatively little option as to whether or not he will undertake war work. If he has either the organzation or the plant, the pressure of public opinion will practically compel him to undertake work needed by the Government. Many kinds of raw materials will be furnished him either directly or by allocation by higher authority. The war contract, therefore, is a very different instrument from the peace-time contract. The draft submitted is framed upon these considerations with the controlling thought that it should attempt to give the Government the things which it requires in an emergency with the least amount of unnecessary trouble or difficulty to the contractor who is conscientiously endeavoring to perform this work. In the effort to arrive at the form which shall best fulfill these conditions, the committee earnestly desires the utmost cooperation from the other party to the conract, namely, the business men of the country. Comment and criticism of the contract is invited from all concerned. All suggestions should be forwarded to Brigadier General W. S. Peirce, Chairman, Office Chief of Ordnance, Munitions Building, Washington, D. C. Copies of the entire form may be obtained upon application.

. . . . . .

ARTICLE III. *Priority*: The contractor shall give this contract precedence over all contracts not directly connected with war activities and as among Federal contracts, in the order of dates of approval thereof, or in accordance with other priority established by competent authority.

. . . . . .

ARTICLE V. *Cost Accounting*: For the purpose of facilitating final settlement by the United States, the contractor shall keep all costs connected with the performance of this contract under the headings and in the manner prescribed by the War Department. All such records shall be preserved by the contractor for a period of two years after the final settlement under this contract.

ARTICLE VI. *Amortization*: Within thirty days after the date of this contract, the contractor shall file with the contracting officer, a list of all property and of all changes in plant with the cost thereof, which he proposes to amortize in whole or in part in the full performance of this contract. Subsequent changes in this list may be made with the approval of the contracting officer. This list, when approved by the contracting officer, shall be the basis for the settlement of all claims for unamortized expenses in the event of termination of work before completion under Article XII of this contract.

. . . . . .

ARTICLE IX. *Payments*: Payments shall be made at such

times and in such amounts as the officer in charge of the work may elect, based upon estimates made by him of the percentage of completion of the contract. Ten per cent (10 per cent.) of such estimates shall be retained until the final completion of this contract and acceptance by the Government of all work done thereunder, except as provided in Article XII; provided, that upon completion and acceptance of each separate building, vessel, distinct public work or group or lot of supplies hereunder, for which the cost is stated separately, payment therefor may be made in full, including the retained percentages thereon, if so completed on or before the time stipulated.

ARTICLE X. *Failure and Delay, Etc.*: In the event of the contractor's failure at any time to carry out the provisions of this contract, or to make satisfactory progress toward its completion, the contracting officer may, by giving written notice to the contractor, proceed under any or all of the following options:

(1) Permit the contractor to proceed with the performance of the contract, under such supervision at the contractor's plant, as the contracting officer may elect to exercise.

(2) Proceed at the contractor's plant to complete the work contracted for, or any part thereof, and for this purpose take posession of and use any or all of the plant, properties and supplies of the contractor, necessary for the performance of this contract.

(3) Purchase or procure from other sources, the articles or services necessary to complete the contract, in such manner as may be deemed best for interests of the public services.

(4) Cancel the contract as to any or all of the uncompleted portions thereof.

In case of proceeding under any or all of the above options, any excess cost over the contract price that may result from the contractor's failure or delay shall be at the expense of the contractor. The contractor, however, shall not be held responsible for delays in the performance of this contract which in the opinion of the contracting officer, were due to causes beyond the control of the contractor, and which could not have been prevented by the exercise of proper effort and business foresight on the part of the contractor; provided, that the contractor shall have promptly and fully notified the contracting officer in writing of any actual or anticipated cause of delay. The contracting officer will then inform the contractor in writing, as promptly as practicable, of his ruling as to the validity of the alleged cause and the extent of delay justified thereby.

ARTICLE XI. *Adjustment of Claims and Disputes*: Except as otherwise specifically provided in this contract, any claims, doubts, or disputes upon matters of fact concerning or arising out of this contract, or as to its performance or nonperformance, and which are not disposed of by mutual agreement, shall be referred to the chief of the Branch named at the head hereof, for determination, and his decision shall be binding and conclusive as to any question, matter or thing so submitted.

ARTICLE XII. *Termination Clause*: Should the war need cease or the public interest require it, work under this contract may be terminated by the United States at any time upon notice in writing from the contracting officer to the contractor. Such termination of work shall be effective upon the date specified in the said notice and shall be without prejudice to any claim which the United States may have against the contractor under Article XI. Immediately upon receipt of such notice, the contractor shall discontinue the placing of all orders for materials, facilities and supplies in connection with the performance of this contract, and shall take the necessary steps to cancel all his existing orders and terminate work under all sub-contracts.

As a full and complete consideration for the termination of work under this contract as hereinabove provided, unless the contractor has been held responsible for failure or delay as provided in Article X, the United States shall, at the time of such termination:

(1) Pay to the contractor the full contract price or compensation for all articles accepted, services rendered or work completed in accordance with the terms of this contract, and not previously paid for.

(2) Reimburse the contractor for all expenditures not included in payments previously made, which had actually been made specifically and necessarily for this contract prior to the receipt by him of notice of termination of work, and for such payments as may subsequently become necessary to effect settlement of all orders and sub-contracts necessarily placed for this contract; provided, such orders and sub-contracts shall have been placed and shall be settled on the basis of the settlement with the contractor herein provided, and with the minimum of expense to the United States. All raw materials, articles in process of manufacture, and other property covered by payments made under any of the terms of this contract shall become the property of the United States, provided, that if the contractor shall have acquired buildings, or parts of buildings, plants, facilities, or equipment solely or in part for the purpose of this contract and not intended or required by him for his future business, or the contractor shall have made changes in his plant which will require expenditures for rehabilitation before resumption of his usual work, or incurred other expenses necessary to this contract and properly intended to be amortized thereunder, he shall be paid such part of his expenditures therefor, as the uncompleted portion of the contract bears to the total contract, less the salvage value of all property involved. He shall also be reimbursed for such portion of the salaries, for thirty days after date of termination of work, of the administrative overhead retained by him strictly for his future business, as was properly chargeable to the terminated work, but no portion of the overhead thus paid shall be included in rehabilitation or other claims for reimbursement.

(3) In the event that the notice of termination of work shall require the immediate cessation of any or all work under this contract and it becomes necessary because of the abrupt cessation thereof, to discharge promptly, any or all of the employees actually engaged upon the termination of work at the date of notice of termination of work, the contractor shall pay to all employees so discharged salaries or wages for forty-five working days after discharge (or to date fixed in Article II for the completion of the contract if less than forty-five days) at two-thirds of the straight rates of pay individually received by them at the date of notice of termination of work. The contractor shall be promptly reimbursed for such expenditures upon the presentation of properly signed and certified pay rolls covering such payments; *provided*, - that no reimbursement shall be made for payment to an employee for any portion of the forty-five days during which he shall have been re-employed by the contractor.

(4) Upon all payments under this contract made the contractor subsequent to the date of termination of work, he shall be allowed interest at six per cent per annum for the period during which any such payment is delayed beyond sixty days after date of termination of the work.

(5) The contractor shall, without additional compensation, place in storage within his plant, and give adequate protection to all property of the United States in his plant, and provide such office space as may be required by the contracting officer and his force at the plant for.....months after the termination of work under this contract, and will thereafter lease the storage required by the United States at not to exceed $..... per square foot per month for a period of not to exceed six months.

(6) The contractor may with the approval of the contracting officer, be permitted to take over such property of the United States as he may desire for his peace time activities, at the prevailing market price, or if none be ascertainable, at a price not greater than the initial cost to the United States.

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Modern Warfare from the French Military Standpoint

The tremendous and increasing importance to our national defense of industrial preparedness is well known. The art of war, like other arts, avails itself to the utmost of the discoveries and inventions in science and industry. As General Williams points out in his article "The Ordnance Problem," in this issue of ARMY ORDNANCE, this is merely the military phase of the industrial revolution which has been in progress for more than a century. It is of course bound to continue indefinitely. There has been no change in the physical make-up of the soldier since history began, but revolutionary changes have been and are taking place in the weapons with which he fights.

The following articles, which appeared in the Army and Navy Journal, are of very timely interest to the members of the Army Ordnance Association as showing clearly the importance of the materiel side of war as viewed by fighting men. In his article "Increased Importance of Materiel," General Buat, Chief of Staff of the French Army, writes as follows:

"If there is a campaign where materiel has played a role of primary importance it is above all that of 1914 to 1918. The firearms of various categories—infantry rifles, machine guns, grenades and field guns—not only have increased in number, but also in their powers of destruction. The consequence has been that the combat methods of the different arms, and notably those of the infantry, have been entirely changed. Where the ground is almost entirely beaten by bullets or by the fragments of bursting shells there is no longer room for objectives either movable or stationary offering an appreciably vulnerable surface to their blows.

Those soldiers who devoted themselves before the war to historical study had little doubt of such a change, because history, to which ultimately it is always necessary to ask light from the past in order to make clear the future, reveals to us in many stages the inexorable law of evolution. The appearance of the first arms caused the deep formations of the middle ages to disappear. Under Louis XIV combat was already carried on by battalions arranged in three ranks. At the end of the reign of Napoleon the suppression of the third rank had already come about. In 1866, during the campaign of sadowa, the Prussians inaugurated the battle tactics of single companies. The first combats of the war of 1870 showed the same Prussians that in the face of the Chassepot rifle of the French army it was no longer the company, but the platoon, a third of the company, which should constitute the smallest infantry battle unit. In 1918 we have come to the group of only a few men united around a machine gun.

Everything leads us to believe that if it had been possible to confine this machine gun to a single infantry soldier, charged with firing it, loading it and advancing with it in the proper direction, our combat group would have been reduced to a single man. This is evidently impossible, and the combat group is the last word at present along the route of the dissemination of the infantry on the battlefield. But as the time is probably not very far away where no group, no matter how small, will be able to march to the attack with unprotected bodies without being exterminated, and as nevertheless it is necessary to attack, because without doing so victory can never be gained, the human imagination must give itself free rein in order to find the means of giving to the assailants at least partial artificial protection, sufficient to permit them to advance actually into the enemy's position.

The tanks, which we have seen become more and more numerous on our battlefields have only resulted from the necessity of some such method.

The effects of firearms must increase in the future. This makes it certain that in increasing the number of our tanks, to the detriment of the infantry, properly said, we are conforming to one of the laws of evolution best indicated by history.

The great war has given to this point of view a striking confirmation, the infantry company, which in 1914 included 250 men, has fallen step by step from 200 to 175, and it was not simply lack of effectives which was the essential cause of this transformation. No, everything points to the increase in the power of armament. There can be no doubt that a small number of men distributed over any given front and admirably armed are for either defense or for attack much stronger and less vulnerable than a much greater number carrying arms of less power.

In the attack in particular, the smaller the number and the more scattered about the more the advantages gained of offering to the enemy's blows a more difficult objective, with the result that a greater number of his bullets and shell fragments are lost in the ground instead of burying themselves in the breasts of the attackers.

At the beginning of the war the French infantry included perhaps 2,000,000 men. When the hour of the armistice sounded its effectives did not number more than a million. However, the sum total of combatants had not sensibly changed. To those who remained infantrymen had been distributed an armament more and more numerous and perfected. To the others had been given posts in the special arms, and notably in the artillery, of which the function is to fire from a distance projectiles destined to help the defense, or the attack of the infantry, or to create, if one wishes to say so, in advance of the infantry, a zone of fire which no human being is able to enter without running the risk of immediate loss of life.

The increase of the artillery in the period from 1914 to 1918 has been formidable. From 200,000 men it increased to more than 700,000. Everything indicates that if hostilities had been prolonged it probably would have been more numerous than the infantry.

It is then a well-confirmed law of history that because of the greater and greater difficulty of remaining alive upon it, the battlefield is little by little emptying itself of all men who are not artificially protected, with the result that there is a steady increase in those branches of the Service which fight protected either by steel or the interposition of a certain distance between themselves and the enemy.

The artillery belongs in the second category. The first is represented by the tanks. However, the artillery itself cannot draw back indefinitely from the front. Now it is probable that with time the zone beaten by intense fire will extend more and more towards the rear of the battlefield.

If this is so, what are we to conclude? Will the artillery also be driven to the two methods of precedure already imposed upon the infantry—to cover and to scatter over the ground? If so, the shields which are now utilized will continue to become larger and larger and thicker and thicker. Also, the scattering of the batteries, both in width and depth, which became a rule at the end of the war, will be even more necessary.

There Must Be a Limit

However, there must ultimately be a limit, because we know that the number of batteries cannot go on increasing, as there will not be sufficient room to scatter them about. Therefore, in the same way that a single machine gun has replaced many rifles, it is possible to imagine a machine served by a small number of men, probably specialists, which will not offer more than a very small surface to enemy projectiles, uniting in itself the power which today is represented by a battery of a number of guns and caissons.

We are consequently launched into that vast domain which many will say is the land of dreams. However, we should not fear to enter it. We are in no danger of losing ourselves as long as we cling tightly to the path pointed out by past evolution. At the most, we can only get several years ahead of our proper time, but if no one ever moved too fast, where would progress come from? Also, if we succeed in making a considerable advance—and a problem once clearly proposed,

it is seldom that some ingenious spirit does not furnish the solution—will it not be to our great advantage?

One word more before finishing. In France, at least, there has been a great deal of discussion on the relative value of what is commonly called the personnel branches of the Service and the materiel branches. This discussion is absolutely vain. As I believe I have shown in the first part of this article, the introduction into the various branches of the Service of more and more materiel has no other effect than to lead to a greater distribution in depth on the battlefield, without in any way diminishing the total number of men employed. This is easily explained. A highly developed materiel generally, able to fire much more rapidly than its predecessors, necessarily leads to a much greater consumption of ammunition, and therefore demands greater means of supply. It might be said that the greater the efficiency of the materiel, the more numerous must be the men attached directly or indirectly to serve it.

An airplane is a striking example. This apparatus, which is managed by two men, and frequently by one, demands for its proper use an additional twenty-five to thirty men to insure its proper functioning and upkeep. Inevitably in the future when a nation places all its available citizens on a war footing. that nation undoubtedly will increase its materiel up to the maximum quantity which can be handled by the personnel available.

In conclusion, it would seem that insofar as the personnel is concerned we should work unremittingly to form good cadres, because good cadres always make good troops. With respect to the materiel, we should prolong beyond today the curve of evolution drawn by the distory of the past and courageously demand of our engineers that they solve the problem of the materiel shown to be necessary for the future. Lack of such materiel in the next conflict will inevitably find us in a state of inferiority in the face of any more far-sighted adversary."—

The second article, "Modern War a War of Mechanics," was written by General Debeney, who is at present President of the French War College

"The World War has revealed the preponderating role of machines. The influence of armament upon operations has been understood for a long time. Also, it has been generally known that in the majority of cases superior armament determined success. In general, however, belligerents have fought throughout a campaign with the same armament with which they began, benefiting from its superiority or suffering from its inferiority. What has never been seen before is the transformation of armament in the middle of combat; the giving to it of an incredible extension, the waiting for a new weapon before starting an operation; in other words, the making of the question of armament into an element of strategy. This had never been seen in Europe, even by those officers who, having studied the American Civil War, know how much the industrial effort of the North influenced and developed the strategy of Lincoln and of Grant.

Modern armament is characterized by the substitution of the collective machine for the individual arm. The individual rifle has given way to the heavy and light machine gun served by several men. The field gun is employed only by batteries provided with an incredible number of engines and instruments destined to alter and direct its fire. The tank and the airplane are machines which demand, besides the crew in them, a complete equipage of numerous auxiliaries whose business it is to keep them supplied, to keep them in order, and to constantly study their development.

The ingenuity of science of all kinds is taxed to furnish war material, telephones, wireless telegraphy, powders and explosives, gas of different natures, and many other things which can only be produced through the efforts of complete workshops make exhaustive demands on electricity, chemistry, metallurgy and other sciences.

This transformation of armament into a series of collective machines has had a considerable influence upon the employment of the personnel of the Army; in other words, upon its effectives.

The public, which is always simple, has a tendency to believe that machinery replaces men, and that in placing in line so many machines it is possible, as a consequence, to send a great number of men home, far from the war. This is not at all true. In fact, more men are needed to serve machines than ever before. If to a tank or airplane were assigned only the two men needed to handle them they could not fight. This for the reason that a considerable personnel is necessary on the spot to which they return after combat, to clean them, to adjust their parts, to supply them with oil and gasoline, and to put up their shelters. Besides, there must be an additional personnel to make spare parts and the additional engines to replace broken ones, because these machines are fragile and do not last very long. In this way each tank and each airplane represents 50 men. Of this number but two are in the first line. The rest are stationed at the parks just off the battlefield, at the different repair depots, and in the factories.

In a general fashion, it may be said that the greater employment of machines has not altered the necessity for large numbers of men, but has merely disposed them differently. Formerly it was the custom to place practically all effectives on the battle line, leaving comparatively few in rear to supply ammunition and materiel. Today ,on the contrary, there is placed in the first line only the personnel necessary for the immediate service and handling of the machines used by the Infantry and Artillery. In the rear are placed the successive echelons of men necessary to look after these machines, to attend to their supply, their repair and their replacement. These echelons stretch as far back as the interior of the country. The war of machines has resulted in the echelonment of the Army in depth. Here is a first characteristic.

A second characteristic is that this materiel cannot be specially manufactured at military arsenals as was formerly the case. Their perfection and their variety are the result of the collaboration of all civilian industries and of all scientific laboratories. In other words, the industries and laboratories of peace time must combine in war to supply the Army. Once war is over, industries return to peace-time work.

For the first time in history the process to be employed in order to put them rapidly at war work is understood. The time saved by such understanding, plus the technical progress which will have been realized by the next war, will insure machinery playing even a more preponderating part. There is no escaping the fact that the war arsenal of a nation consists of its peace-time laboratories and industries. This second characteristic is a very grave one.

Whether we wish it or not, it is thus the whole country, both from the point of view of personnel and materiel, which must take part in war. The passage from a peace basis to a war one is only possible through some form of general mobilization of the whole nation.

In the war of machinery, a nation which wishes to defend its independence must prepare, besides the mobilization of its man power, the mobilization of its industry and that of all its economic and administrative elements. The time has come when the nation in arms is a verity.

The formidable operation of mobilization necessitates both time and absolute security. It can only be completed if protected from enemy attack by a strong force of covering troops along the frontier nearest the enemy.

The best protection is furnished by large oceans, because a first-class Navy is all that is necessary to insure complete mobilization of the nation. Such is the case of the United States, which only has to fear serious menace on its maritime frontier. France is in an entirely different situation. Its most menaced frontier is a land one with no natural obstacles. Thus her covering force must consist of a numerous Army well provided with a powerful armament. Each country will solve the problem according to its means and its particular situation. In France it is solved by means of obligatory service, which is in accordance with our democratic ideas, and which in the end costs infinitely less than a professional army.

Personally I think that the commercial development of aviation will make great changes in the solution of the problem of a covering force. The day will come when dirigible balloons and airplanes will be sufficiently perfected to fly practically continuously, carrying great weights and going almost anywhere. Then they will offer such advantages to commercial exploitation that they will be as numerous as is now the case with auto trucks and automobiles. When this time arrives, air fleets will constitute a true army of the air alongside of the army of the sea, commonly called the navy, and the army of the ground, commonly called the army. The existence of an air army will completely transform the problem of a covering force, because sea frontiers and land frontiers will no longer be the only ones to defend. However, this is a problem which we cannot solve now. It is necessary to keep track of the latest developments and continually work upon the possibilities of using them for war purposes. . . .

Machines themselves are not able to act alone. Therefore it is always the man who has the last word.